SCIENCE

VOL. 82 [illegible] FRIDAY, SEPTEMBER 6, 1935 No. 2123

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal
Lancaster, Pa. Garrison, N. Y.
Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

FORM, DRIFT AND RHYTHM OF THE CONTINENTS[1]

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IT is now sixty-seven years since the British Association enjoyed the hospitality of the city of Norwich, a privilege which is being renewed to-day under the most happy auspices.

At that meeting we find the scientific community was particularly interested in underground temperatures and tidal phenomena, in the application of the spectroscope to celestial objects, and in the discovery of the oldest Cambrian fossils and the earliest fossil mammals then known. Many papers were read on local natural history, including those on Norfolk farming and the drainage of the county and of the fens.

In his address at the meeting the president, Sir Joseph D. Hooker, made special reference to the work of Charles Darwin: not to the "Origin of Species," which had been acrimoniously discussed by the association on previous occasions, and notably at Oxford in 1860, but to some of the work that followed.

It should be remembered that Hooker was one of the three scientific men, representing botany, zoology and geology, whom Darwin had selected as judges with whose opinion on the soundness of his theory of the origin of species he would be content. The others were Huxley and Lyell; and of the three, Lyell was the hardest to convince, chiefly because the record of life in the past then furnished by the rocks was manifestly so incomplete and unsatisfactory that its evidence was insufficient to warrant a definite verdict.

Lyell had set out to "treat of such features of the economy of existing nature, animate and inanimate, as are illustrative of geology," and to make "an investigation of the permanent effects of causes now in

[1] Address of the president of the British Association for the Advancement of Science, Norwich, September 4, 1935.

action which may serve as records to after ages of the present condition of the earth and its inhabitants." By laborious study of the work of others and by his own extensive travel and research, he had been able to enunciate, for the inorganic world, the principle of uniformitarianism, which in its original form we owe to Hutton. This principle involved that the history revealed by the rocks should be read as the effect of the slow but continuous operation of causes, most of them small, such as could be seen in action in some part or other of the world to-day. This was set in opposition to the opinion of the older geologists who had postulated a succession of catastrophes which, by flood, fire and convulsion, had periodically wrecked the world and destroyed its inhabitants; each catastrophe necessitating a new creation to provide the succession of life on the earth as it then was known.

But in the organic world Lyell, like Hutton, had failed to detect any analogous principle and, as he rejected all the theories of transmutation of species then in vogue, he had to accept their absolute fixity; and to suppose that, as species became extinct one after another, replacement by special creations followed. And yet the reading to-day of the chapters devoted to this branch in the earlier editions of Lyell's great work produces the haunting feeling that a better explanation had only just eluded him. It was the story revealed in Lyell's work, Darwin tells us, the new conception that the earth had been in existence for vast eons of time, the proof that it had been continuously peopled by animals and plants and that these had steadily advanced and improved throughout that time, which showed him the necessity for an explanation of the progression of life and gave him the first hints of this theory. When he had enunciated that he was enabled to repay his master with the principle of organic evolution, which brought changes in the animate world into harmony with those of the inanimate.

His "Antiquity of Man" shows that by 1863 Lyell had become a convert, and he afterwards rewrote much of the second volume of his "Principles" accepting the new point of view. This change earned from Hooker a testimonial in the 1868 address which, if not unique, must certainly be one of the most magnificent ever awarded to a scientific work:

> I know no brighter example of heroism, of its kind, than this, of an author thus abandoning, late in life, a theory which he had regarded as one of the foundation stones of a work that had given him the highest position attainable amongst contemporary scientific writers. Well may he be proud of a superstructure, raised on the foundation of an insecure doctrine, when he finds that he can underpin it and substitute a new foundation: and, after all is finished, survey his edifice, not only more secure, but more harmonious in proportions than before.

Although infinitely richer than when Darwin wrote, the geological record still is, and must from its very nature remain, imperfect. Every major group of animal life but the vertebrates is represented in the Cambrian fauna, and the scant relics that have been recovered from earlier rocks give very little idea of what had gone before, and no evidence whatever as to the beginnings of life.

But, from Cambrian time onward, the chain of life is continuous and unbroken. Type after type has arisen, flourished and attained dominion. Some of them have met extinction in the heyday of their development; others have slowly dwindled away; others, again, have not finished their downhill journey or are still advancing to their climax.

Study of the succession of rocks and the organisms contained in them, in every case in which evidence is sufficiently abundant and particularly among the vertebrates and in the later stages of geological history, has now revealed that the great majority of species show close affinities with those which preceded and with those which followed them; that, indeed, they have been derived from their predecessors and gave origin to their successors. We may now fairly claim that paleontology has lifted the theory of evolution of organisms from the limbo of hypothesis into a fact completely demonstrated by the integral chain of life which links the animals and plants of to-day with the earliest of their forerunners of the most remote past.

Further, the rocks themselves yield proof of the geographical changes undergone by the earth during its physical history; and indicate with perfect clearness that these changes have been so closely attendant on variation in life and the incoming of new species that it is impossible to deny a relation of cause and effect.

Indeed, when we realize the delicate adjustment of all life to the four elements of the ancients which environ it—air, water, earth and fire—to their composition, interrelationships and circulation, it is perhaps one of the most remarkable facts established by geology that, in spite of the physical changes which we know to have occurred, the chain of life has never snapped in all the hundreds of millions of years through which its history has been traced.

The physical changes with which Lyell and his successors were most closely concerned were, firstly, the formation of stratified rocks on horizontal sea-floors, situated in what is now often the interior of continents, far removed from the oceans of the present day, and thus indicating important and repeated changes in the position of land and water; and, secondly, the deformation of these flat deposits till they were rucked and ridged to build the mountain ranges.

Before and since Lyell's time geologists have devoted themselves to working out the exact and detailed

succession of these stratified rocks, translating their sequence into history and their characters into terms of geography; the succession of physical conditions prevailing at the time of their formation. Further, although animals and plants migrate from place to place, the time occupied by the migrations of suitable forms is so negligible when compared with the length of the chapters of geological history that their fossil remains have proved to be the best means for correlating strata over broad stretches of the earth's surface. This correlation has converted the fragments of local history thus revealed into at least the outlines of the geological story of the world.

It was not till 1885, however, that the accumulation of data of this type was sufficient to enable the great geologist, Suess, an Austrian but born in this country, to assemble and correlate them and to deduce from them further principles which have been the mainstay and inspiration of his successors. We owe to Hertha Sollas and her father the rendering of this great work, "The Face of the Earth," into English; and to Emmanuel de Margerie and his colleagues a French translation enriched with a magnificent series of maps and sections such as could only have been brought together by one with the most remarkable bibliographic knowledge; a veritable recension of the original.

The nature and associations and the distribution in time and space of modern changes in the relative levels of land and sea, as detected at sea-margins and by altitude survey, and of older changes betrayed by such evidence as submerged forests and raised beaches, had convinced geologists that the unstable element was not the fickle and mobile sea, but the solid if elastic earth-crust. They naturally applied the same explanation to those encroachments of the sea in the past which had resulted in the formation of our stratified rocks. But while some investigators were content with one form of movement—that due to lateral pressure—to explain both the formation of mountains and the rise and fall of the land, others called in a different cause for the latter. Without entering into a discussion of causes it may be well for us to distinguish the orogenic or mountain-forming from the epeirogenic or continental movement.

The evidence collected by Suess proved that these last great land and sea changes had occurred simultaneously over whole continents or even wider regions. Such great submergences as those to which the Cambrian Rocks, the Oxford Clay and the Chalk are due were of this character; while, in between, there came times of broad expansions of continental land and regressions of the sea. These changes were in his view on far too grand a scale to be compared with, or explained by, the trivial upheavals and depressions of land margins of the present day, which he showed could mostly be correlated with volcanoes or earthquakes or with such incidents as the imposition or relief of ice-sheets on an elastic crust in connection with glacial conditions.

It became necessary for him to replace or supplement oscillations of the earth-crust by a world-wide periodic ebb and flow of the oceans, to and from the continents; positive movements of transgression carrying the sea and its deposits over the lands, drowning them and their features under tens or hundreds of fathoms of water; and negative movements or regressions when the oceans retreated to the deeps, leaving the continents bare or encrusted with recently formed sediments.

Although the facts cried out for this generalization Suess was at a loss to supply any mechanism competent to produce the wonderful rhythm. The problem was difficult because a liquid must maintain a horizontal, *i.e.*, an equipotential, surface. It was manifestly impossible to withdraw from the earth, and later to replace upon it, the vast quantity of water that would be required; and, though a shifted water-level or even a varied water-surface relative to the continents might be caused by polar ice-caps, by redistribution of the continents carrying their local effects on gravitation, by variations in the rate of the earth's rotation or other far-reaching causes, none of these would supply an explanation that fitted all the facts. Regressions of the sea could be to some extent explained if Suess's main postulate, that the great ocean basins had been slowly sinking throughout geological time, were granted. But this explanation only rendered more impotent the raising of ocean levels by deposits of sediment, and this was almost the only valid cause for transgressions that he had been able to suggest.

Further, it is not possible to ignore the definite relationship that exists between the pulsation of the oceans and the raising of mountains by lateral or tangential stress. Periods of positive movement or advance of the seas were times of comparative tranquility, when tangential pressure was in abeyance. Periods of negative movement and retreat were invariably marked by the operation of great stresses by which the earth's face was ridged and wrinkled in the throes of mountain-birth.

The theory that continuous cooling and shrinkage of the interior of the earth afforded an explanation of mountain ranges and other rugosities on its surface was a legacy from the nebular hypothesis. In spite of the homely simile of a shriveling apple, this explanation has never received a very enthusiastic welcome from geologists, though, in default of other resources, they had to make use of it. As knowledge has grown the difficulties have become insurmountable to them.

First, there is its inadequacy to explain the vast amount of lateral movement required to account for the greater mountain ranges; their rocks, originally spread over a wider area, having been folded and crushed into a narrower width. The shortening of the earth-crust thus effected has been estimated in the case of the Rocky Mountains at 29 miles, of the Himalayas at 62, the Alps at 76 and the Appalachians at the large figure of 200 miles.

Then there is the periodicity of mountain growth. The great epochs of mountain-building, such as the Caledonian, to which the chief Scottish and Welsh mountains are due, the Hercynian, responsible for the Pennine and South Wales, and the Alpine, which gave us "the wooded, dim, blue goodness of the Weald," were associated with vast continental development; and each was separated from the next by a period of relative inactivity lasting dozens of millions of years.

Further, there is the fact that the vigor of mountain-building, of volcanoes and of other manifestations of unrest has shown no sign of senility or lack of energy. The geologically recent Alpine-Himalayan range is as great, as lofty and as complicated in structure as were any of its precursors. The active volcanoes of Kilauea, Krakatao or St. Pierre, and those recently extinct in Northern Ireland and the Scottish Isles, were as violent and efficient as any of those of the Paleozoic Era. The earth is "a lady of a certain age," but she has contrived to preserve her youth and energy as well as her beauty.

But it was when Lord Kelvin's dictum struck from geology its grandest conception, time, that it became vital to reexamine the position. He had demonstrated that, if the earth had been continuously cooling down at its present rate, its surface must have been too hot for the existence of life upon it a limited number of million years ago. The concept of geological time, indicated by Hutton in his famous saying that in this inquiry "we find no vestige of a beginning—no prospect of an end," had been confirmed by data accumulated through the painstaking researches of a host of competent and devoted observers all over the world. To them, familiar with the tremendous changes, organic and inorganic, that the earth had passed through since Cambrian time, it was wholly impossible to compress the life story of the earth, or the history of life upon it, into a paltry 20 or 30 million years. The slow growth and slow decay of mountain range after mountain range, each built out of and in some cases upon the ruins of its predecessor, the chain of slowly evolving organisms, vast in numbers and infinite in variety, told plainly of long eons of time. And the duration of these eons can be dimly realized when it is recalled that, within a small fraction of the latest of them, man, with the most primitive of implements and the most rudimentary culture, has succeeded in penetrating to the uttermost corners of the world, and developed his innumerable languages and civilizations.

Huxley, as our representative, took up the challenge in his address to the Geological Society in 1869, and asked the pertinent question, "But is the earth nothing but a cooling mass 'like a hot water jar such as is used in carriages' or 'a globe of sandstone'?" And he was able to point out at least some agencies which might regenerate the earth's heat or delay its loss.

So it is only fitting that the great physicist, who imposed a narrow limit to geological time, should have prepared the way for those who have proved that the earth possesses in its radioactive substances a "hidden reserve" capable of supplying a continuous recrudescence of the energy wasted by radiation, thus lengthening out the time required to complete its total loss. These later physicists have given us time without stint; and, though this time is the merest fraction of that envisaged by cosmogonists and astronomers, we are now so much richer than our original estimates that we are embarrassed by the wealth poured into our hands. So far from the last century's urge to "hurry up our phenomena," we are almost at a loss for phenomena enough to fill up the time.

The far-sighted genius of Lord Rutherford and Lord Rayleigh first saw the bearing of the rate of disintegration of radioactive substances in the minerals of rocks on the age of the parts of the earth-crust built of them. The extension and supplementing of this work by Joly, Holmes and others has now enabled us to look to the disintegration of uranium, thorium and potassium, as the most promising of many methods that have been used in the endeavor to ascertain the age of those parts of the earth-crust that are accessible to observation. These methods also promise a means of dating the geological succession of eras and periods in terms of millions if not hundreds of thousands of years.

The decline and early death to which Lord Kelvin's dictum had condemned the earth, according so little with the vigor displayed in its geological story, is now transformed into a history of prolonged though not perennial youth. It was for Joly, of whose work the extent, variety and fruitfulness are hardly yet fully appreciated, to take the next step and see in the release of radioactive energy a mechanism which could drive the pulse that geologists had so long felt and that Suess had so brilliantly diagnosed. As Darwin found the missing word for Lyell, so Joly in his theory of thermal cycles has indicated the direction of search for a mechanism to actuate the rhythm of Suess.

In Joly's conception the running down of the earth's energy, though a continuous process, was, through the

intervention of radioactivity, converted into a series of cycles, during each of which relative movements of sea and land must occur; downward movements of the continents, associated with positive encroachments of the sea; upward movements with retreat of the sea, the formation of wide land masses and the ridging of strata to form mountain ranges. Thus he forged a link that could unite the continental or epeirogenic movement with orogenic or mountain movement.

The visible parts of mountains and continents, as well as their lower and hidden portions, or "roots," are made of comparatively light rocks. In order to stand up as they do their roots must be embedded in denser matter, in which they "float" like icebergs in water. A far larger mass must exist below than is visible above, and the bigger the upstanding part the bigger the submerged root. Over the larger area of the ocean floor, on the other hand, the thickness of material of low density must be very slight, and the denser layer must come close to the surface.

The study of earthquakes, to which the Seismology Committee of the British Association has made outstanding contributions, has yielded, from the times taken in transmission of vibrations through the earth, the best information as to the nature and state of the interior. It has proved that the dense layer is solid at the present time. It is probably no coincidence that the earth is also but just recovering from what is possibly the greatest period of mountain-building, if not the greatest negative movement of ocean retreat, that it has ever experienced.

But solidity can not be the permanent condition of the substratum. Heat is generated in it by its own radioactivity, but, according to the terms of the hypothesis, can not escape, in consequence of the higher temperature generated in the continental rocks which cover it. It is therefore retained in the substratum and stored as latent heat of liquefaction, so that, within a period which has been calculated approximately in millions of years, complete melting of the sub-crust must ensue.

The resulting expansion of the liquefied stratum will have at least two effects of great importance to us. In the first place, the unexpanded superficial layers will be too small to fit the swelling interior. They will, therefore, suffer tension, greater on the ocean floor than on land, and cracking and rifting will occur, with intrusion and extrusion of molten rock. In the second place, the continental masses, now truly floating in a substratum which has become fluid and less dense than before, will sink deeper into it, suffering displacement along the rift cracks or other planes of dislocation. As a result the ocean waters, unchanged in volume, must encroach on the edges of the continents, and spread farther and farther over their surfaces.

Thus we have the mechanism which Suess vainly sought, causing positive movements of the oceans, their waters spreading over wide stretches of what was formerly continental land and laying down as sediment upon it the marine stratified rocks which are our chief witness of the rhythmic advances of the sea.

This condition, however, can not be permanent, for by convection of the fluid basic substratum, supplemented by the influence of tides within it and the slow westward tidal drag of the continental masses towards and over what had been ocean floor, there will now be dissipation of its heat, mainly into the ocean waters, at a rate much faster than it has been or could be accumulated. Resolidification ensues, and again there are two main consequences. First, the stratum embedding their roots having now become more dense, the continental masses rise, and as they do so the ocean waters retreat from their margins and epicontinental seas, leaving bare as new land, made of the recently deposited sediments, the areas previously drowned. Secondly, the expanded crust, left insufficiently supported by the withdrawal of shrunken substratum, will suffer from severe tangential stress and, on yielding, will wrinkle like the skin of a withering apple. The wrinkles will be mountain ranges, formed along lines of weakness such as those at continental margins; and they will be piled up and elevated to suffer from the intense erosion due to water action upon their exposed and upraised rocks.

In this, again, we have a mechanism which supplies what was needed by Suess, and one, moreover, which secures the required relationship between continental and mountain movement, between the broader extensions of continental land and the growth of mountains with their volcanoes and earthquakes and the other concomitants of lateral thrust.

Thus a thermal cycle may run its full course from the solid substratum, through a period of liquefaction accompanied by crustal tension, back to solidification and an era of lateral stress; and the stage is set for a new cycle.

Professor Arthur Holmes, in checking Joly's calculations, has concluded that the length of the cycles in a basic rock substratum should occupy from 25 to 40 million years, a period much too short to fit the major periods of mountain movement, as determined by him from the radioactivity of minerals contained in the rocks. On this evidence the Alpine movement should date back from 20 to 60 millions of years ago, the Hercynian 200 to 250 millions and the Caledonian from 350 to 375 million years.

In a preliminary attempt to modify Joly's hypothesis Holmes postulated the occurrence of similar but longer cycles (Magmatic Cycles) in a denser, ultrabasic layer underlying the basic one, the rhythm of which would be nearer to 150 million years. The

shorter cycles due to the basic layer are held in part responsible for periods of minor disturbance, and also to account for the individual variations in effect, duration and intensity of the larger ones. Each of the later movements has also evidently been limited and conditioned by the results of foregoing ones and especially by areas of fracture and weakness, on the one hand, and by large stable masses composed of rocks intensely consolidated or already closely packed, on the other.

More recently Holmes has developed the possibility that the loss of heat is mainly due to convection in the liquid substrata and that convection is the leading cause of the drifting and other movements of the crust and the disturbances that have occurred in it. He says:

> Although the hypothesis involving sub-crustal convection currents can not be regarded as established, it is encouraging to find that it is consistent with a wide range of geological and geophysical data. Moreover, it is by no means independent of the best features of the other hypothesis. It requires the local operation of thermal cycles within the crust, and it necessarily involves contraction in regions where crustal cooling takes place. It is sufficiently complex to match the astonishing complexities of geological history, and sufficiently startling to stimulate research in many directions.

The phenomena are difficult to disentangle, as the number of operating causes has been so great and many of them are not fully understood. But underlying them all there is unquestionably the pulse within pulse which Suess saw and of which Joly pointed the way to explanation.

The view at which we have arrived is neither strictly uniformitarian nor strictly catastrophic, but takes the best from each hypothesis. As Lyell showed, most of the phenomena of geology can be matched somewhere and some time on the earth of to-day; but it would appear that they have varied in place, intensity, phase and time. And, as Lyell was driven to accept *evolution* to explain the history of life on the earth, so must we employ the same word to express the life-processes of the earth itself, as was suggested by Huxley in 1869 and strongly advocated by Sollas in 1883.

The contrast in outline and structure between the Atlantic and Pacific Oceans had long been noted when Suess formulated and used the differences as the basis of his classification.

The Pacific is bounded everywhere by steep slopes, rising abruptly from profound ocean depths to lofty lands crowned with mountain ranges, parallel to its shores and surrounding its whole area. On the American side the Coast Range is continued by the Andes. On the Asiatic side chains of mountainous peninsulas and islands, separated from the continent by shallow inland seas, extend in festoons from Kamchatka and Japan to the East Indies, eastern Australia and New Zealand. This mountain ring, as Charles Lapworth said, "is ablaze with volcanoes and creeping with earthquakes," testifying that it has been recently formed and is still unfinished.

The Atlantic Ocean, on the other hand, is not bordered with continuous ranges, but breaks across them all: the Scottish and Welsh ranges, the Armorican range, the continuation of the Pyrenees and Atlas; and, on the American side, the uplands of Labrador, Newfoundland and the eastern states and the hill ranges of Guiana and Brazil. The Atlantic is in disconformity with the grain of the land, while the Pacific conforms with it. The Pacific has the rock-folds of its ranges breaking like ocean waves towards it, as though the land were being driven by pressure to advance upon it, while the Atlantic recalls the effects of fracture under tension.

The middle and southern edges of the Atlantic, however, agree to some extent with the Pacific type. The Caribbean Sea, with the Antilles and the rest of its border girdle, recalls the similar structure of the Mediterranean, as it stretches eastwards, with breaks, to the East Indian Archipelago; while the Andes are continued to Antarctica in a sweeping curve of islands. The rest of the Indian Ocean is of Atlantic type, as seen in the shores of eastern Africa and western Australia.

Another feature of the Atlantic is the parallelism of much of its eastern and western coasts, the meaning of which has often attracted the speculation of geologists and geographers. With a little stretch of the imagination, and some ingenuity and elasticity of adjustment, plans or maps of the opposite sides may be fitted fairly closely, particularly if we plot and assemble the real edges of the continents, the steep slopes which divide the "shelves" on which they stand from the ocean depths. This has suggested the possibility that the two sides may once have been united, and have since broken and drifted apart till they are now separated by the ocean.

This view, outlined by others, has been emphasized by Wegener and dealt with by him in full detail in his work on "The Origin of Continents and Oceans," and it now plays a leading part in what is known as the Wegener theory of continental drift. The hypothesis is supported by the close resemblances in the rocks and fossils of many ages in western Europe and Britain to those of eastern North America; by community of the structures by which these rocks are affected; and by the strong likeness exhibited by the living animals and plants on the two sides, so that they can only be referred to a single biological and distributional unit, the Palearctic Region.

The hypothesis, however, did not stop at this; and in the South Atlantic and certain other areas Wegener and his followers have also given good reasons for believing that continental masses, once continuous, have drifted apart.

Broad areas in southern Africa are built of rocks known as the Karroo Formation, of which the lower part, of late Carboniferous age, is characterized especially by species of the strange fern-like fossil plants Glossopteris and Gangamopteris. Associated with them are peculiar groups of fossil shells and fossil amphibia and reptiles. Similar rocks, with similar associations and contents, in Peninsular India have been named the Gondwana Formation. Comparable formations also occupy large regions in Australia, Tasmania and New Zealand, in Madagascar, in the Falkland Islands and Brazil and in Antarctica.

The correspondence between these areas is so close that Suess supposed they must at that date have been connected together by lands, now sunk beneath the sea, and he named the continent thus formed Gondwanaland after the Indian occurrences. The break-up of this land can be followed from a study of the rocks, and it was a slow process, its steps occupying much of Mesozoic time. Dr. A. L. Du Toit's comparison of South African rocks with those of Brazil and elsewhere in South America favors even a closer union than this between the units now scattered.

One of the most remarkable features shown by these rocks in all the areas mentioned, but to varying extents, is the presence of conglomerates made of far-traveled boulders, scratched like those borne by the modern ice-sheets of Greenland and the Antarctic, associated with other deposits of a glacial nature and often resting upon typical glaciated surfaces. There is no possible escape from the conclusion that these areas, now situated in or near the tropics, suffered an intense glaciation. This was not a case of mere alpine glaciers, for the land was of low relief and not far removed from sea-level, but of extensive ice-sheets on a far larger scale than the glaciation of the northern parts of the new and old worlds in the Pleistocene Ice Age. I have never seen any geological evidence more impressive or convincing than that displayed at Nooitgedacht, near Kimberley; while the illustrations and other evidence published by David and Howchin from Australia are equally striking.

Du Toit's work on these glacial deposits brings out two remarkable facts; first, that the movement of the ice was southerly, pole-ward and away from the equator, the opposite to what would be expected, and to the direction of the Pleistocene ice-movement; secondly, that the ice in Natal invaded the land from what is now sea to the northeast.

When it is realized that at this period there is no evidence of glacial action in northern Europe or America, but a climate in which grew the vegetation that formed the coal seams of our coal measures, it is clear that we are not dealing with any general refrigeration of the globe, even if that would produce such widespread glaciation: we are face to face with a special glaciation of Gondwanaland.

On both sides of the Atlantic these glacial episodes in Carboniferous times were followed by dry and desert climates in Triassic time, and these by violent volcanic outbursts. Nor are the rocks alike only in mode of formation—the structures by which they are traversed correspond; while even in details there is remarkable agreement, as in the peculiar manganese deposits, and the occurrence of diamonds in "pipes" of igneous rock, both east and west of the ocean.

Rather than face the difficulties presented by the subsidence of lands connecting the severed portions of Gondwanaland, as pictured by Suess, Wegener has preferred, and in this he is supported by Du Toit and many other geologists, to bring into contact these severed parts, which could be fitted together as nearly as might be expected, considering the dates of severance. Du Toit's map of the period places South America to the west and south of South Africa, Madagascar and India to the east, Antarctica to the south and Australia farther to the southeast. Such a grouping would form a continent much less wide in extent than that envisaged by Suess and would offer some explanation of the more remarkable features of the glaciation in the several areas, as well as the problems of the rocks, fossils and structures involved.

In its application to the geology of Gondwanaland the modified hypothesis of Wegener cuts a Gordian knot; but it still leaves a great climatal difficulty, unless we take his further step and conceive that at this date the terrestrial south pole was situated within Gondwanaland. No shift in the axis on which the earth rotates would, of course, be possible, nor is it postulated—only a drifting at that date of continental land across the pole.

If a hypothesis of drift be admitted for Gondwanaland, it would be illogical to deny its application to other regions, including the north Atlantic. I have already mentioned some facts in its favor. Others are the resemblances of all sedimentary rocks on the two sides from the Cambrian to the Ordovician and from the Devonian to the Trias; the links between the structures of the land, as, for instance, between Ireland and Newfoundland; and the instance given by Professor Bailey in his address to Section C in 1928. As Bailey then pointed out, the great Caledonian range which crosses Scotland, northern England and Wales from northeast to southwest on its course from Scandinavia is affected and displaced by the east to west Armorican

(Hercynian) chain extending across from Brittany to South Wales. "The crossing of the chains, begun in the British Isles, is completed in New England"; and from here the Armorican structure continues its westerly course. This is where it should cross if the continent of North America were brought back across the Atlantic and placed in the position which, according to Wegener, it would fit into in the European coast! Can the Pilgrim Fathers have ever dreamed of such a link between the Old England and the New?

The hypothesis of continental drift gave rich promise of solving so many difficult problems that it was hailed by many classes of investigators almost as a panacea. Geographers have seen in it an explanation of the forms of continents and the position of peninsulas, islands and mountains; meteorologists have found it the solution of some of the problems of past climates and their anomalies of distribution over the world; biologists hope to get help with the intense complexities in the distribution of forms of life and many strange facts in migration, and paleontologists with similar difficulties among the ancient faunas and floras as revealed by their fossil remains; geodesists have welcomed escape from the rising and sinking of the crust, so difficult to reconcile with the demands of isostatic equilibrium; and it has been already stated that drift forms a vital factor in Joly's thermal cycles.

But there has been no lack of criticism in all these directions. It has been assailed on the one hand for the detail attempted in its geographical restorations, and on the other hand for its vagueness. Professor Schuchert quotes Termier as saying that it is "a beautiful dream, the dream of a great poet. One tries to embrace it, and finds that he has in his arms but a little vapor or smoke: it is at the same time alluring and intangible." It has been objected that "no plausible explanation of the mechanics involved has been offered"; that the continental connections postulated present by no means so close a match, when fitted together, as has been claimed, in the structure or the nature of either igneous or sedimentary rocks; that there is good evidence of extensive vertical movements in recent earthquakes, in the accumulation of tremendous thicknesses of sediment indicative of shallow-water from base to summit and in the growth of coral reefs; that Central America and the Mediterranean are a difficult obstacle; and that the known distribution of the Karroo fossil reptiles is not by any means what the hypothesis demands.

If the idea of drift be accepted it can not be regarded as a royal road out of all our difficulties, nor can it be the only form of earth-movement to be reckoned with. The late J. W. Gregory, whose life was sacrificed to geological discovery, has studied exhaustively the geological history of the Atlantic and Pacific Oceans, both as revealed by the sedimentary rocks and fossils on their borders, and by the distribution of life to-day. He finds that, according to our present knowledge, in the two oceans, facilities for migration have fluctuated from time to time, periods of great community of organisms alternating with periods of diversity. Again, at some times connection seems to have been established north of the equator, at others to the south; and we can not ignore the possibility of migration across polar lands or seas when terrestrial climates have differed from the present. The facts of life distribution are far too complex to be explained by any single period of connection followed by a definite breaking apart, even if that took place by stages. Mrs. Reid, too, has pointed out that resemblances between the Tertiary floras of America and Europe actually increased at the time when the Atlantic should have been widening. Unless continental drift has been a more complicated process than any one has yet conceived, it seems impossible to escape from some form of the "land bridges" of the older naturalists:

> Air-roads over islands lost—
> Ages since 'neath Ocean lost—

We have no right to expect greater simplicity in the life of a planet than in that of an organism.

As the question of drift must in the last appeal be one of fact, it is not unnaturally expected that the real answer will come from measurements of longitude and latitude with greater exactness and over periods longer than has yet been possible. None of the measurements hitherto made has indicated variations greater than the limits of errors of observation. Two things, however, may militate against a definite answer from this source. Many parts of the crust, such as the shield-like masses of Archean rock, may have completed their movement, or be now moving so slowly that the movement could not be measured. Careful selection of locality is essential, and at present we have little guidance. Also, as the displacement of crust must be dependent on the condition of its substratum, it will be a periodic phenomenon and the rate of movement may vary much in time. According to the theory of thermal cycles the sub-crust is at present solid and may not permit of drift. Drift, according to Joly and Holmes, is a cyclical phenomenon; if present-day observations were to give a negative result they would not necessarily disprove it.

The occurrence of recumbent rock-folds and nearly horizontal slides or "nappes" in mountain regions give positive proof that parts of the upper earth-crust have moved over the lower. In the northwest Highlands of Scotland a sliding of at least ten miles was proved by Peach and Horne, and in Scandinavia it

amounts to sixty miles. For mountain packing as a whole the figures already given are far larger, while in Asia Argand has stated that packing of over 2,000 miles has occurred. Thus, when all is said and done, movements on a colossal scale are established facts, and the question of the future is how far we shall accept the scheme of drift due to Wegener or one or other of the modifications of it. It is for us to watch and test all the data under our own observation, feeling sure that we shall have to adapt to our own case Galileo's words "e pur si muove."

Ever since it was realized that the inclination and folding of rocks must be attributed to lateral or tangential stress and not solely to uplift, shrinkage of the interior of the earth from its crust has been accepted as the prime mover, and whichever of the current theories we adopt we can not deny the efficacy of so powerful a cause.

The general course of events in the formation of a mountain range is fairly well known: The slow sinking of a downfold in the crust during long ages; the filling of this with sediment *pari passu* with the sinking, and associated softening of the sub-crust due to accumulated heat; the oncoming of lateral pressure causing wave-like folds in the sediments and the base on which they rest; the crushing of folds together till, like water waves, they bend over and break by overdriving from above or, it may be, under-driving from below; fracture of the compressed folds and the traveling forward for great distances of slivers or "nappes" or rock, generally of small relative thickness but of great length and breadth, and sliding upon floors of crushed rock; the outpouring and intrusion of igneous rocks, lubricating contacts and complicating the loading of the sediments; metamorphism of many of the rocks by crystallization at elevated temperatures and under stress, with the development of a new and elaborate system of planes of reorientation and movement; and elevation of the whole, either independently or by thickening with compression and piling up to bring about a fresh equilibrium.

Such a course of events would be brought about by lateral pressure developed during the consolidation phase of each of the thermal or magmatic cycles. At each period of their building, mountains have arisen along lines of weakness in the crust, especially coast lines and the steep slopes marking the limits between continents and ocean basins. This is consistent with Joly's theory that the thrust of ocean beds against land margins is the cause.

But the advocates of continental drift point to the siting of ranges across the paths along which the drifting movement is supposed to have occurred, and they consider that the moving masses are responsible; and indeed that the ridging and packing of the crust has in the end checked and stopped the movement. They note that the great western ranges of America occur in the path of any western drift of that continent, the Himalayas in the course of the postulated movement of India, the East Indies in front of Australia; and that the Alpine ranges of Europe may be linked with the crushing of Africa towards the north.

The "nappes" of rock, cut off from their origin and sliding for dozens of miles, are a constant source of wonder to all who have considered the mechanics of mountain formation. They are so thin as compared with their great length and breadth that it seems impossible to imagine them moved by any force other than one which would make itself felt throughout their every particle. Such a force is gravitation, and it is of interest that some Alpine geologists and Dr. Harold Jeffreys have used it in explanation of them. Professor Daly has also adopted gravitation on an even greater scale in his theory of continental sliding: and one can not fail to notice the increasing use of the term "crust-creep" by those working on earth-movement.

Is there no other force, comparable in its method of action to gravitation, but capable of producing movement of the earth-crust in a direction other than downhill? Is it not possible, for instance, that the tidal influence of the moon and sun, which is producing so much distortion of the solid earth that the ocean tides are less than they would be otherwise, and, dragging always in one direction is slowing down the earth's rotation, may exert permanent distorting influence on the solid earth itself? May it not be that such a stress, if not sufficiently powerful to produce the greater displacements of continental drift and mountain-building, may yet take advantage of structures of weakness produced by other causes, and itself contribute to the formation of nappes and to other movements of a nature at present unexplained?

Our knowledge of geology has been gained by the survey of the rocks, the study of their structures and the delineation of both upon maps and sections. This work is being accomplished by geologists all over the world, and this country and its dependencies have contributed their full share. It is therefore opportune to note that there has just been celebrated the centenary of the Geological Survey of Britain and, with it, the opening of the new Geological Museum at South Kensington.

A century ago H. T. De la Beche, one of the devoted band of pioneer workers then studying the geology of the country, offered to "affix geological colors to the new maps of Devon and Cornwall" then in course of issue by the Ordnance Survey. His offer was accepted, and, at his own expense and on his own feet, he carried out a geological survey of some 4,000 square miles. In 1835 he was appointed to continue this task, with a small salary and a few assistants. Thus was started the first official geological survey, an example widely fol-

lowed by other nations and dominions. De la Beche's conception included also a museum of economic and practical geology, a library, a record of mines, for which he secured support from a strong committee of the British Association in 1838 and a school of mines for the scientific and technical education of those to be employed in the survey or exploitation of mineral resources. In these objects, and especially the last, he was warmly supported by the Prince Consort. He lived to see his visions all come true, as he collected round himself that wonderful band of surveyors, investigators, writers and teachers, which included such men as Playfair, Logan, Ramsay, Aveline, Jukes, Forbes, Percy, Hooker and Huxley.

Some of the schemes he planned have budded off and grown into large and important entities, rendering conspicuous service to scientific record, education and research. But the main duties of the Geological Survey remained with it and have been carried on for a century. These are to map the geology of the country on the largest practicable scale, to describe and interpret the structure of the land, to preserve the evidence on which conclusions have been founded and to illustrate for students and other workers the geology of the country and its applications to economics and industry. The broad detail of the structure of the whole country is now known, but much new work must be done to keep abreast of or to lead geological thought. For instance, the study of the cloak of "superficial deposits," which often cover and conceal the structure of the more solid rocks below, is essential for the proper understanding of soils and agriculture; and a knowledge of the deep-seated geology of the country, which is often widely different from that nearer the surface and thus very difficult to interpret, is vital to the community for the successful location and working of coal and iron, and for tracing supplies of water and oil and other resources at depth.

Evolution of life on the earth has been by no means uniform; there have been periods of waxing and waning which may be attributed to geographical, climatological and biological influences. The development of large land areas, ranged longitudinally or latitudinally, the invasion of epicontinental seas, the isolation of mediterraneans or inland seas, the splitting of continental areas into archipelagos or the reunion of islands into continuous land, the making of barriers by the rearing of mountain chains or the formation of straits or arms of the sea, the oncoming of desert or glacial climates—all such factors and many others have been of importance in quickening or checking competition and in accelerating or retarding the evolution of life.

Probably, however, even greater effects have followed the interaction of groups of biological changes on one another. As an instance I might recall Starkie Gardner's estimate of the results following upon the first appearance of grasses in the world. This seems to have been not earlier than Eocene, and probably late Eocene times. By the Oligocene they had made good their hold, peculiarities in their growth and structure enabling them to compete with the other vegetation that then existed; and gradually they spread over huge areas of the earth's surface, formerly occupied by marsh, scrub and forest. They have, as Ruskin says, "a very little strength . . . and a few delicate long lines meeting at a point . . . made, as it seems, only to be trodden on to-day, and to-morrow to be cast into the oven"; but, through their easy growth, their disregard of trampling and grazing and by reason of the nourishment concentrated in their seeds, they provided an ideal and plentiful source of food. On their establishment we find that groups of animals, which had previously browsed on shrubs and trees, adopted them, with consequent alterations and adaptations in their teeth and other bodily structures. To follow their food from over-grazed or sun-scorched regions they required to be able to migrate easily and quickly, and it was essential for them to discard sedentary defense and to flee from threatened danger. Such defense as was possible with heels, teeth or horns, they retained; but the dominant modifications in their organization were in the direction of speed as their most vital need.

Side by side with this development, and in answer to increasing numbers, came bigger, stronger and speedier carnivores, to feed on prey now so much more abundant, but more difficult to catch. The answer of the grass-feeders, with their specialized hoofs, teeth and bones, better suited to flight than fight, was to seek safety in numbers and thus develop the herd instinct, with its necessity for leadership and discipline; but this, in turn, provoked a like rejoinder from some types of their enemies.

When it is remembered how much of the meat and drink and life of mankind is bound up with the grasses, including wheat, maize, millet and other grains, sugar-cane, rice and bamboo, we must realize how close is his link with the development just outlined. Practically his whole food supply is provided by them, either directly by the agriculturist, who grows little else but grasses, or indirectly by the herdsman, whose domestic animals are fed chiefly on the same food. Nor must we forget that almost every one of our domesticated animals has been derived from the gregarious types just mentioned, which have accepted the leadership of man in place of that of their own species.

It is perhaps not too much to say that the magnificent outburst of energy put out by the earth in the

erection of the Alps, Andes and Himalayas in Tertiary times was trivial in its influence for man's advent and his successful occupation of the earth in comparison with the gentle but insidious growth of "mere unconquerable grass" and its green carpet of "wise turf" which in some form clothes by far the greater part of the land of the globe.

The kind of developmental reaction of which this is but a single example must clearly have had influence on bodily features other than bones and horns, teeth and claws, speed and strength; and one of the most striking has been on intellectual development and the size and shape of brain.

We do not, and perhaps can never, know the quality of the material of which the brains of fossil creatures were made, for we have no instrument to pierce the veil of time as the spectroscope has penetrated the abysm of space. But we are even now learning something about their shapes and convolutions, and more about their mass in its relation to the size of the bodies controlled; from the time of the earliest Ordovician fishes, through the history of the amphibia, reptiles, birds and mammals, up to man himself.

The brain of those gigantic if somewhat grotesque reptiles, the dinosaurs, the tyrants of Mesozoic time, is relatively tiny. In Diplodocus, 80 feet in length and 20 tons in weight, the brain was about the size of a large hen's egg. It is true that there was a big supplementary sacral ganglion which may have taken chief charge of locomotion and helped to secure coordination throughout the hinder part of its huge length and bulk; but of true brain there was not more than a quarter of an ounce to control each ton of body and limb; and we begin to understand why they lost the lordship of creation.

The proportion of brain to body improved in those reptiles which took to flying, possibly in relation to their acquisition of warm blood, and in the birds evolved from reptiles; but it is only in mammals that a marked advance is seen. Here the brain of Uintatherium, a great rhinoceros-like animal of Eocene date, weighing 2 tons, was about the size of that of a dog. This proportion of half a pound of brain to each ton of body shows how far the mammals had gone and still had to go.

A 12-stone man of the present day has about 3½ pounds of brain—an amount not far short of half a hundredweight per ton.

Even though we can know nothing of its material, this steadfast growth in the guiding principle, through the millions of centuries that have gone to its development, is surely one of the most remarkable conclusions that we owe to geology. Of all the wonders of the universe of which we have present knowledge, from the electron to the atom, from the virus and bacillus to the oak and the elephant, from the tiniest meteor to the most magnificent nebula, surely there is nothing to surpass the brain of man. An instrument capable of controlling every thought and action of the human body, the most intricate and efficient piece of mechanism ever devised; of piercing the secrets and defining the laws of nature; of recording and recalling every adventure of the individual from his cradle to his grave; of inspiring or of ruling great masses of mankind; of producing all the gems of speech and song, of poetry and art, that adorn the world, all the thoughts of philosophy and all the triumphs of imagination and insight—it is indeed the greatest marvel of all.

And when we contemplate the time and energy, the sacrifice and devotion, that this evolution has cost, we must feel that we are still far from the end of this mighty purpose, that we can confidently look forward to the further advance which alone could justify the design and skill lavished on this great task throughout the golden ages that have gone.

SCIENTIFIC EVENTS

REPORT OF THE BRITISH FORESTRY COMMISSIONERS

A GENERAL review of the first fifteen years' work of the British forestry commissioners and also of the quinquennium, 1929–34, is given in the annual report for the year ended September 30, 1934. As summarized in the London *Times*, it notes that increasing attention has been given to the utilization of home-grown timber. At present the amount of home-grown timber cut in the forests is not large compared with the total felled in the country. Sales of forest produce have averaged £54,680 a year over the last five years, whereas the total value of home-grown timber felled for sale or estate use was estimated in 1930 to amount to £1,545,340. At the same time it is expected that the proportion of state-owned timber sold must gradually increase.

The total area of plantations was 316,000 acres, including 250,000 acres planted or replanted and 66,000 acres acquired and transferred under the Transfer of Woods Act, 1923. There are also 228,000 acres awaiting planting. The ultimate forest area is consequently 544,000 acres, which compares with 367,000 acres five years previously.

The total number of forest units was 186, an increase of 35 in five years. The rate of increase has slowed up owing partly to the reduction in acquisitions and partly to the fact that with a larger total number

of units it is often impossible to add new acquisitions to existing units. In 1934 the average unit contained 2,900 acres of plantable land compared with 2,400 acres in 1929. Of the 186 units 74 are in England, 27 in Wales and Monmouth and 85 in Scotland.

Developments in forest technique are recorded, and, with regard to education, it is stated that the average attendance of forestry students at the Universities of Oxford, Cambridge, Bangor, Edinburgh and Aberdeen was approximately 160 a year and in the 15-year period some 524 degrees and 222 diplomas were awarded. The Imperial Forestry Institute, established at Oxford in 1924 for post-graduate instruction, has been attended during the 10 years by 274 students.

Interest in the countryside and the preservation of its distinctive character and amenities has increased greatly, according to the *Times*, in the last few years, and the report shows that, in the course of managing the New Forest, it has become apparent that still wider recreational use might be made of unplantable land. This area more nearly conforms to the general conception of a national park than any other in Great Britain. There are no means of estimating the number of people who visit or use the New Forest in the course of the year, but there must be many tens of thousands. For campers alone some 800 to 900 permits are issued annually. Of all the numerous ancient Royal forests only two—Dean Forest and New Forest—have survived, haphazard, in a form which affords opportunity for both timber production and public recreation. It appears to the commissioners that by taking a little thought and possibly incurring a little additional expenditure in the utilization of the land acquired for the new forests, it may be possible to provide, for the future, areas as highly prized by the public as is the New Forest to-day.

The commissioners have recently been in communication with the Council for the Preservation of Rural England on the subject of the relation of forestry and afforestation to the amenities of the countryside and a joint informal committee has been formed for the discussion of outstanding questions.

PETROLEUM LABORATORIES OF THE BUREAU OF MINES

Industrial and Engineering Chemistry states that plans for future activities of the research laboratory at the Amarillo, Texas, Helium Plant have been announced by Dr. John W. Finch, director of the U. S. Bureau of Mines. The laboratory staff, which in the past has been concerned largely with work relating to production and conservation of helium, will direct its efforts toward studies of technical problems involved in production and utilization of petroleum and natural gas. The Amarillo laboratory is one of the best equipped in the country for research on properties of gases at low temperatures.

The laboratory at Amarillo will make studies of physical and thermal properties of petroleum mixtures that have influence on their flow through the producing sands and in wells, using specialized experience and technique developed in the research that has done so much to improve methods and reduce costs of extracting helium from natural gas. Also the activities of the research group at Amarillo will include special studies of the causes and prevention of freezing in high-pressure, natural gas pipe lines, often experienced at temperatures many degrees above the normal freezing point of water. This work will be closely correlated with investigations of flow of natural gas through pipe lines, which have been under way at the bureau's experiment station at Bartlesville, Okla.

The petroleum research activities at Amarillo, as well as the continued operation of the government-owned helium plant and 50,000 acres of natural gas properties, will be under the general direction of R. A. Cattell, chief engineer of the Petroleum and Natural Gas Division, with headquarters in Washington, D. C. C. W. Seibel, supervising engineer of the helium plant, will be in administrative charge at Amarillo, and several petroleum technicians will be added to his staff to aid in the petroleum research centered there.

The petroleum field office of the bureau at Laramie, Wyo., is being reopened as a result of a provision in the appropriation for the fiscal year ending June 30, 1936, for establishing and operating a petroleum experiment station on the campus of the University of Wyoming. Offices and laboratories are now in temporary quarters but will be moved to a new building to be erected by the university. The office was closed on June 30, 1933, because of reduction in funds available for oil and gas investigations. The staff will begin work with a general survey of the Rocky Mountain oil fields and refineries.

MOTION PICTURE FILMS OF THE NATIONAL ARCHIVES OF THE UNITED STATES

A CORRESPONDENT of *The New York Times* calls attention to a measure establishing a national archives of the United States, which has recently been enacted. This section reads:

> The National Archives also may accept, store, and preserve motion picture films and sound recordings pertaining to and illustrative of historical activities of the United States, and in connection therewith maintain a projecting room for showing such films and reproducing such sound recordings for historical purposes and study.

The "projecting room" is a small theater, equipped with the latest and finest in motion picture equip-

ment, and having a seating capacity of about 225. It will never be open to the public, but is reserved for the use of accredited research students and scholars.

So far as is known, this is the most extensive effort by any country to provide for the central collection and storing of historic materials through the medium of motion pictures. The *Times* writes:

> The question arises as to what benefit will accrue to scholars from the privilege of viewing "old" films when the average life of a film is only about fifteen years. In this connection the chief concern of Captain John G. Bradley, in charge of the division, is the problem of preservation. He has the assistance of the National Research Council, the United States Bureau of Standards, the Carnegie Foundation and a number of private companies and film chemists in this work.
>
> Stored in a special library, each nitrate film is to be placed in an elaborate ventilated compartment. By control of the humidity and temperature of the air and the removal of all deterrent gases, it is hoped to lengthen the life of films from fifty to a hundred years, instead of their present fifteen, and finally, by duplication, to preserve them in perpetuity.

In stocking this remarkable library, the difficulty is one of selection. According to the *Times*, some accessions will be made by transfer from other government agencies of records of such epoch-making events in the life of the nation as inaugural processions, dedication services, Indian life, etc.

The second means of supply, by gift, is one into which the exercise of much discrimination enters. Leading motion picture producers have offered rare films, while the Motion Picture Academy has offered its prize-winning plays. There will not be room to keep more than a small percentage of the gifts proffered and so far none of them have been accepted.

With the consent of Congress and under authority of the National Historical Publications Commission, pictures may be purchased or recorded. These two provisions of the act, however, have not yet been invoked.

AN INTERNE SYSTEM FOR MUSEUMS

ESTABLISHMENT of an interne system to train candidates for museum work, similar to the system in use for many years in training men for the medical profession, has been announced, according to *The New York Times*, by Philip N. Youtz, director of the Brooklyn Museum, in Eastern Parkway. The Rockefeller Foundation has offered funds for six fellowships to make possible this system, the first of its kind in museums.

"This project," Mr. Youtz said, in presenting the plan to the Rockefeller Foundation, "provides a means by which candidates for museum positions and younger members of the profession may have a period of practical experience in a socially oriented museum where they will not only learn methods of presenting museum material to the public but where they will become acutely conscious of their obligation to the public.

The Rockefeller Foundation approved the plan on June 21 and expressed its preference for men who were thoroughly grounded academically and who were most certain to find places of leadership in the museum profession, either as curators or executives.

It is expected that the first interneships will be started on September 1. Candidates have been recommended by Professor Paul J. Sachs, associate director of the Fogg Art Museum of Harvard University and president of the American Association of Museums; Laurence Vail Coleman, director of the American Association of Museums; Horace H. F. Jayne, director of University Museum, University of Pennsylvania; Theodore Sizer, associate director of the Gallery of Fine Arts, Yale University; Professor Charles Rufus Morey, of Princeton University, and Dr. Walter W. S. Cook, chairman of the Fine Arts Graduate Center, New York University.

Professor Sachs, a sponsor of the plan, wrote: "The whole subject has long seemed to me of fundamental importance. I have advocated it for years. I made it the burden of my presidential address at the meeting of the American Association of Museums in 1934, in Toronto, and this year in Washington. I am satisfied that important results will be achieved."

FEDERAL FELLOWSHIPS FOR HEALTH OFFICERS

ACCORDING to a statement received from Science Service, over $1,000,000 of the funds assigned to the United States Health Service in the social security program will, if the funds are appropriated, be used within the next year to train personnel for state and local health departments. Plans for this training by means of short- and long-term fellowships are being drawn up by officers of the service following suggestions made by the recent Conference of State and Territorial Health Officers.

In outlining these plans, Dr. C. E. Waller, U. S. Public Health officer in charge of this phase of the program, pointed out that such provision for the training of health department personnel is one of the most important developments in public health in this country. Never, even during the depression, have there been enough trained workers for health departments, the demand for trained medical health officers especially having always exceeded the supply.

Two types of training courses were suggested by the Conference of State and Territorial Health Officers. Details for setting these up are now being worked out

by officers of the U. S. Public Health Service in consultation with state health officers, and if the money becomes available, the program is expected to be in full swing by the end of the fiscal year. Short-term fellowships will be given to nurses to train them for public-health nursing, to physicians to train them to act as public health officers, and to civil engineers to train them as sanitary engineers.

The academic part of this training will be given at various centers throughout the country. One such training center will serve a number of states. Existing educational institutions will be used, selected according to suitability of location and of facilities for such training. Where such facilities need to be enlarged, this will be done, the cost to be prorated among the states served and to be paid for out of their share of the social security funds for public health. Following the academic training the students will be given an opportunity to gain experience of practical work in the field through special field demonstration centers which are to be set up.

Fellowships for longer training courses will also be given, this training to be obtained at the Schools of Public Health already established at a number of universities. Awards of both kinds of fellowships will be made by the state health officers. In making these awards they have for their guidance suggestions of the Conference of State and Territorial Health Officers as to qualifications of applicants for such training for public health work.

RECENT DEATHS AND MEMORIALS

DR. HENRY BRIGGS, Hood professor of mining at the University of Edinburgh since 1924, when the chair was established, professor of mining at Heriot-Watt College since 1919 and technical adviser to the British War Office during the war, died on August 26 at the age of fifty-two years.

HENRY ADAMS, consulting engineer and architect, for thirty-five years professor of engineering at the City of London College, died on August 15, at the age of eighty-nine years.

THE death is announced of Dr. Wilhelm Sieglin, professor of historical geography at the University of Munich, and of Dr. Hermann Emde, professor of pharmacology and the chemistry of nutrition at Königsberg.

To celebrate the centenary of the birth of Simon Newcomb, a cairn erected by the Historic Sites and Monuments Board of Canada, four miles from Wallace, Nova Scotia, where he was born, was unveiled on August 30, 1935, by his daughter, Mrs. Joseph Whitney, of Washington. Those present at the dedication included Norman Armour, ambassador of the United States to Canada; Lieutenant-Governor Walter Covert, of Nova Scotia; Premier Macdonald and Chief Justice Sir Joseph Chisholm, of Nova Scotia, and Professor D. C. Harvey, a member of the board. Professor Albert Einstein in a message read at the ceremonies, said, "He was one of the outstanding masters of celestial mechanics." It was because of Newcomb's work that "the infinitely small deviations of the Newtonian principles of mechanics from the actual motions of the celestial bodies have become known with tolerable precision and certainty."

A CORRESPONDENT of the London *Times* in the issue of August 20 writes: "To-day is the twentieth anniversary of the death of Paul Ehrlich, the great bacteriologist. He is most famous for his discovery of 'Salvarsan' or '606,' a cure for syphilis, but two years earlier, in 1908, he had already divided the Nobel prize for medicine with Professor Metchnikoff for their investigations in immunity. To Ehrlich more than to any other man is due the present treatment of infectious diseases with strong chemical preparations which destroy the microbes without damaging the host. It was largely his insistence which led to the wide use of intravenous injection, much against the will of clinicians of his day. In his search for specific preparations to cure disease he has been justly dubbed 'the first real follower of the great Paracelsus.' Paul Ehrlich was born of Jewish parents on March 14, 1854, at Strehlen, in Silesia. His earliest, and some of his best, work was done with the aid of dyes, and in 1908 he discovered the dye 'trypan red,' which was capable of curing trypanosome infection in mice. He died on August 20, 1915, when *The Times*, transcending the animosities of the war, wrote: 'The vast number of problems he set himself bear witness to the strength of his imagination. He opened "new doors to the unknown," and the whole world at this hour is his debtor.' Only in his own country has he lately been without honor; and the celebration which was to have been held on what would have been his eightieth birthday was forbidden."

SCIENTIFIC NOTES AND NEWS

DR. GRIFFITH EVANS, of Bangor, North Wales, veterinary surgeon, known for his work in protozoology, who first associated trypanosomes with the production of disease, celebrated his hundredth birthday on August 7.

DR. GEORGE A. HULETT, who joined the department of chemistry at Princeton University in 1892, becoming professor of physical chemistry in 1909, retired from active service at the end of the college year.

DR. CHARLES E. KELLOGG, of the Bureau of Chem-

istry and Soils of the U. S. Department of Agriculture, has been appointed chief of the Soil Survey Division. He succeeds Dr. Curtis F. Marbut, who died on August 25. Dr. Kellogg is called upon to direct the most extensive program of soil survey and land classification which his division has yet been asked to carry out, including important work in cooperation with such governmental agencies as the Tennessee Valley Authority and the Agricultural Adjustment Administration.

DR. KNIGHT DUNLAP, professor of psychology at the Johns Hopkins University, has accepted a similar position at the University of California at Los Angeles. He succeeds the late Shepherd Ivory Franz. Dr. Dunlap was visiting professor of psychology at Los Angeles during the spring semester of 1935. He will take up the work of the position in February, 1936.

DR. CLARENCE A. PATTEN, associate professor of neurology at the University of Pennsylvania Graduate School of Medicine, has been appointed professor of neurology to succeed the late Dr. Theodore H. Weisenburg.

DR. ALFRED M. LUCAS, assistant professor of cytology, Washington University Medical School, St. Louis, has been appointed associate professor of zoology at the Iowa State College.

DR. ELDON THORP, research associate at the Scripps Institution of Oceanography of the University of California, has been elected professor of geology and geography at Baylor University, to succeed the late Dr. Frank Carney.

EDWARD TELLER, of Hungary, a theoretical physicist, who has recently been engaged in research at the University of London, will join the faculty of the George Washington University as visiting professor of physics for the coming year. In addition to the courses that he will give, Dr. Teller will offer a series of public lectures, following up those on modern physics given at the university last winter by Dr. Gamow. He also will take part in the Conference on Theoretical Physics held annually under the joint auspices of the Carnegie Institution of Washington and the George Washington University, which this year will place the emphasis on certain problems related to chemistry.

DELEGATES to the seventh American Scientific Congress, to be held in Mexico City from September 8 to 17, have been appointed by the United States Government as follows: Dr. Cloyd Heck Marvin, president of the George Washington University, *chairman;* Dr. Wallace Walter Atwood, president of Clark University; J. McKeen Cattell, editor of SCIENCE, New York; Dr. Franklin Stewart Harris, president of Brigham Young University, Provo, Utah; Dr. Edward V. Huntington, professor of mechanics, Harvard University; Neil M. Judd, curator of archeology, U. S. National Museum; France V. Scholes, Division of Historical Research of the Carnegie Institution of Washington, and William W. Schott, second secretary of the American Embassy, Mexico City.

DE PAUL UNIVERSITY, Chicago, at its summer commencement, conferred *in absentia* the honorary doctorate in science upon Dr. Carlos E. Porter, the Chilean entomologist. The citation, read by the chairman of the University Council, was: "Professor Doctor Carlos E. Porter: Chevalier of the Crown of Italy, professor in the National University and in the Catholic University of Chile; president of the National Academy of Natural Sciences; vice-president of the International Faculty of Sciences of Great Britain; medallist of many organizations in various foreign lands for distinctive service; director of the Institute of General and Systematic Zoology; author of untold numbers of scientific articles and volumes; honorary member of more than one hundred foreign scientific societies, and decorated by three governments—who, by his intensive research in such important scientific fields as that of poisonous spiders and his contributions in the realm of yellow fever, has made the world his debtor—who has brought to the world's ken many new species of insects, of fossil molluscs and of hitherto unknown plants—who founded the world-famed *Chilean Review of Natural History* which for thirty-eight years has owed its inspiration and its wide influence to its founder—and who above all has been the most outstanding scientist on an entire continent— who by his work has made the world conscious of the great work that is being done in the world of science in Latin America—is entitled to the highest honor that a university can confer—and De Paul University this day honors itself in honoring Latin America's most distinguished scientist, by conferring upon him the degree of Doctor of Science, *honoris causa.*"

IN honor of Dr. Witmer Stone, vice-president of the Academy of Natural Sciences of Philadelphia, who has made a life-long study of the birds and plants in that region, an emergency landing field for migrant birds has been established at Cape May Point, N. J. The project is under the auspices of the National Association of Audubon Societies, with the support of the New Jersey Audubon Society. The tract is a natural concentration ground for many thousands of migrant birds.

DR. J. DUFRENOY, director of the Station of Plant Pathology at Bordeaux, France, who visited the United States at the time of the Chicago Exposition, has re-

ceived from the Ministry of Colonies the decoration of Chevalier de l'Ordre de l'Etoile Noire in recognition of his work at the Institute of Colonial Agriculture.

DR. RICHARD PFEIFFER, professor of hygiene at the University of Breslau, has been elected an honorary member of the Royal Society of Medicine, London.

THE Medical Faculty of the University of Berne, Switzerland, has awarded a prize of 1,000 Swiss francs to Dr. Leslie T. Webster, of the Rockefeller Institute for Medical Research, for his investigations in the field of encephalitis.

DR. WILLIAM C. ANDERSON, dean of the Brooklyn College of Pharmacy, was recently elected president of the New York State Pharmaceutical Association.

L. F. LIVINGSTON, formerly of the agricultural engineering staff of the University of Wisconsin, was elected president of the American Society of Agricultural Engineers at the recent convention at Athens, Georgia.

DR. CARL E. LADD, dean of agriculture and home economics at Cornell University, has been appointed by Governor Lehman one of five members of a committee to study rural electrification in New York State.

HENRY FAIRFIELD OSBORN, JR., son of the honorary president of the American Museum of Natural History, has been named director of the New York Division of the National Youth Administration.

PROFESSOR J. A. NIXON, professor of medicine at the University of Bristol, and Dr. R. E. Lane have been appointed members of the British Industrial Health Research Board.

THE British Medical Research Council, according to *Nature*, has undertaken to promote investigation into the question whether various volatile substances might injure the health of workers using them under industrial conditions. The council has appointed the following special committee to assist and advise in this matter: Sir Joseph Barcroft (*chairman*), J. C. Bridge, Professor A. J. Clark, Professor A. G. Green, Professor J. A. Gunn, Professor E. H. Kettle, Dr. H. B. Morgan, J. Davidson Pratt, D. R. Wilson and Sir David Munro, *secretary*.

DR. JOHN T. HALSEY, professor of pharmacology at Tulane University, has this summer been making investigations at the Woods Hole Marine Biological Laboratory on the effect of pituitary extracts on the blood pressure of fishes. Associated with him in the work are Drs. Margaret M. Lewis and Earl O. Butcher.

DR. DONALD F. JONES, president of the Genetics Society of America and head of the department of genetics at the Agricultural Experimental Station at New Haven, Conn., has been granted a leave of absence beginning on September 1. He will work at the California Institute of Technology at Pasadena.

DR. ISSAC, second imperial entomologist, Pusa, India, after attending the Imperial Entomological Conference in London, will visit the United States, Puerto Rico and the Hawaiian Islands. He plans to study methods of pest control in regard to sugar cane.

THE seventeenth International Geological Congress will take place in Moscow in the summer of 1937. Reports will be made on the oil problem and the calculation of its total world deposits, the geology of coal deposits, the deposits of rare elements and geophysical methods in geology.

THE International Pacific Health Conference takes place at the School of Public Health and Tropical Medicine in the University of Sydney from September 3 to 6. Among the subjects to be discussed are leprosy, malaria and intestinal infections. The dates of the sessions have been so arranged that delegates will be enabled to go to Melbourne to attend the annual meeting of the British Medical Association, which begins on September 9. It was expected that at least twenty-two institutions in the Pacific would be represented at the conference in addition to Australian delegates.

THE Belgian Society of Ophthalmology, on the occasion of the International Exhibition, will hold a special meeting at Brussels on September 22, to which all ophthalmologists are invited.

AT the request of the German Minister of the Interior the German Society of Neurologists has become merged with the German Association of Neurologists and Psychiatrists under the presidency of Professor Rudin of Munich.

THE sum of $10,000 has been bequeathed to the New York Botanical Garden through the will of the late Mrs. Mary Strong Shattuck.

THE *Journal* of the American Medical Association states that the West Virginia University School of Medicine, Morgantown, which was disapproved by the Council on Medical Education and Hospitals of the American Medical Association in February without prejudice to the students enrolled, is undergoing a complete reorganization. Plans are largely matured and are being carried out as rapidly as possible in an attempt to maintain a school of small size and high standards.

THE departments of botany, zoology, bacteriology, agronomy, horticulture, animal husbandry and landscape architecture of Brigham Young University at Provo, Utah, will be moved in the near future into

larger, better equipped laboratories and offices in the new George H. Brimhall Building, now nearing completion on University Hill. The late Dr. Brimhall was president of the university from 1903 to 1921, when he became president emeritus and professor of religious education.

THE *St. Louis Post-Dispatch* reports that seven Russian geologists, exploring for the first time the crater of Kliutcheff volcano in the Kamchatka Peninsula, barely escaped with their lives when the crater suddenly filled with smoke and sulfur gas. The expedition, which was sent out by the Academy of Sciences, is said to have pulled to the top with most of its members in a semi-asphixiated condition. Kliutcheff is 15,750 feet high.

A PWA appropriation to scientific and medical institutions in New York City includes: To supplement the staff in the Department of Health's clinics, baby health stations, school hygiene and tuberculosis registration—$321,732. To enable the twenty-six city hospitals to cope with demands, including additional hospital help, social, medical and nursing service, clerical and research work—$4,112,148. For the New York Botanical Garden to carry on labeling and preparing descriptions of various plants and for genetic studies —$149,340. For laboratory and curatorial assistance in the Brooklyn Botanic Garden—$55,654. For study involving tabulation and analysis of meteorological data to provide a basis for the rendition of accurate visibility forecasts in the Port of New York—$13,740.

DISCUSSION

EARTHQUAKE PREDICTION

EVERY once in a while, as recently, the claim that earthquakes can be predicted is brought to public attention in the press or in other ways. Some of the claimants are obviously not competent; others proceed along rational lines but without due regard to the difficulties involved. Some may be publicity seekers; others are undoubtedly sincere.

In a recent number of SCIENCE, July 12, 1935, Dr. H. Landsberg stated quite correctly that in the present state of knowledge reliable earthquake prediction is impossible; and he went on to mention briefly some of the lines of research which have been suggested as prerequisite to any competent prediction, neglecting to mention others equally or more important, for example, study of foreshocks and measurement of strain by geodetic means.

To have any useful meaning the prediction of an earthquake must indicate accurately, ***within narrow limits,*** the region or district where and the time when it will occur—and, unless otherwise specified, it must refer to a shock of important size and strength, since small shocks are very frequent in all seismic regions.

On the other hand, generalized forecasting of the occurrence of shocks in regions known to be seismically active is entirely possible, but this is not earthquake prediction in the proper sense. The exact, or even approximate, time, place and magnitude can not be stated; only that shocks will occur and that some will be strong, so that proper safeguards should be set up to minimize the risk incurred from them.

Earthquake prediction has two aspects, one relating to the development of seismologic science and one relating to public welfare. With respect to the latter, unless and until such prediction can be reduced to a very precise procedure, giving place, time and magnitude reliably and almost infallibly, the public announcement of a prediction is likely to be harmful and mischievous, causing unwarranted worry and apprehension among large numbers of the population. On the other hand, even only approximately successful forecasting of earthquake occurrence on a rational basis, or even only empirically, would be an important forward step in seismology, for it would mean the attainment of a better understanding of the action of the forces which produce earthquakes, or at least a better grasp of their occurrence statistically. Such prediction or forecasting should not be made public in the press, however, but simply notified to proper scientific groups who would subject it to test as to its realization and rational method, to determine its value.

Most of the earthquake prophets who are sincere do not realize the obstacles which confront successful prediction—the limitations as to place of occurrence and the high frequency of occurrence of shocks.

In the very strictest sense we do not know what causes earthquakes, but the evidence is well-nigh overwhelming that nearly all are caused by the sudden release of elastic strain when rock strained beyond its strength breaks and slips in geologic faulting, with attendant friction and vibration and the radiation of elastic waves. (A few other earthquakes are, or may be, due to underground collapse or rock-fall or explosion or sudden magma movement in volcanoes.) Again in a very strict sense we do not know whether the rock strain is developed suddenly or slowly, but once more the evidence is very strong that in most cases it is of slow growth, due to forces active in the

bending and warping of rock in the process of mountain building. However, it is possible that such strain could be of rapid growth due to sudden changes in bulk, or relatively rapid movement in magma, beneath the surface. Such a possibility must be kept in mind. The cause of deep-focus shocks presents a problem as yet unsolved. At any rate it is in regions of recent and present-day mountain development that all but a negligible fraction of earthquakes occur, both great and small. And the rocks strain whose sudden release is the proximate cause of them is not *built* by gravitational or tidal forces, variations in barometric pressure, wandering of the pole (variation of latitude), or other similar cyclical or sporadic forces of small magnitude, though such stresses may on occasion add their mite at the critical epoch and act as "trigger" forces to *release* the strain. The rock will break and slip, however, when it can no longer withstand the strain, whether or not the action of such a trigger coincides with the time of rupture.

Of the "trigger" forces probably the tidal stresses are the most important—though earthquakes have occurred at times when a steep barometric gradient crossed the originating fault at a large angle, and there is apparent correlation with abrupt changes in the variation of latitude. The gravitational attraction due to the moon is known to produce tides in the solid crust of the earth with an up-and-down movement twice in one day which in many regions frequently exceeds one foot in amplitude. Similar effects produced by the attraction of the sun are about two fifths of those of the moon, while effects due to the planets are only an exceedingly small fraction of those due to the sun. If these gravitational forces really act effectively in precipitating the occurrence of shocks there should be a clear and unequivocal parallelism between the frequency of shock occurrence and the changes in amount and direction of gravitational attraction. Statistics, however, show that in many earthquake regions such a parallelism definitely does not exist, while in other seismic districts such a correspondence is found to a slight extent but by far too small to afford a satisfactory basis for earthquake prediction. This is to be expected, since such forces can not set off shocks except in regions already greatly strained by other causes, and as long as we do not know what regions are already highly strained, the degree of strain nor the amount or direction of the geologic forces responsible, we can not judge when or where trigger forces can be effective.

Unless the region or district, not too great in area, and the exact or closely approximate time, and the shock magnitude are stated—any earthquake prediction stands a good chance of apparent verification because of the great number of shocks which occur in all seismic regions in a given period. If a vague prediction is made and news of a shock is sought to check it, a vague verification is more than likely to be obtained. Notwithstanding this, a majority of such predictions have failed. In 1930, the latest year for which the International Seismological Summary is completely available, many more than 7,000 earthquakes were reported to the central bureau at Oxford University by seismological stations in many parts of the earth. These are very far from being all the shocks which occurred in that year, for not all seismological stations made report to Oxford, and, more important, there are wide regions in which small and moderate shocks are numerous where there are no instruments to record them. Finally, in general only a few of the thousands of aftershocks following a strong earthquake are reported. However, probably all or nearly all large and very large shocks in 1930 are included in the summary. In that year 653 shocks were recorded well enough and widely enough for their epicenters to be determined closely or approximately. A few of these were small shocks, and a small number were aftershocks of important earthquakes. More than 400, however, were large enough to be registered over an area 40° or more (say 3,000 miles) in diameter, and of these some 178 were large enough to be registered over an area of one half of the earth's surface or more. There were but few days on which a large or moderately large shock did not occur, and there was no day on which fewer than 7 shocks were reported to Oxford. In nearly all seismic regions shocks occurred at frequent intervals. The ease of obtaining apparent verification of a prediction vague as to time, place and size, and the difficulty of making a very precise prediction are obvious from the above considerations.

Prediction on the basis of astronomical or tidal hypothesis is not new. It has always failed in the past, and recent predictions on such a basis have in part failed completely and in part obtained vague verification which has no meaning as indicated above.

Any moderately successful method of prediction for scientific testing will be welcomed by all seismologists, but public prediction in the present state of knowledge is nothing short of a menace. Generalized forecasting, on the other hand, is not a menace but is a duty which informed men of science owe to the population of seismically active lands.

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SENSORY MASKING—A PERIPHERAL OR A CENTRAL PHENOMENON?

DAVIS and Derbyshire[1] have recently reported that "Auditory masking is the diminution of audibility of one sound caused by the presence of a second sound. Study of the electrical responses of the cochlea and of the auditory nerve of the cat shows that this phenomenon depends primarily on the refractory period of the nerve fibers." In other words, nerve impulses initiated by one sound fail to reach the sensorium because blocked by the refractory periods following the passage of impulses generated by another sound; the phenomenon is *peripheral,* depends upon the physiological properties of the nerve fiber and is of the nature of a functional block.

It has been observed in this laboratory[2,3,4] that if, in a conscious person, a cutaneous nerve be stimulated through the skin with a suitable alternating current, a characteristic tingling is felt in the cutaneous area supplied by the nerve, and perception of touch, pressure and pain in that area is dulled. Possibly here, similarly, impulses initiated by the stimuli applied to the skin may be blocked by the refractory periods set up by the electrical stimuli applied to the nerve. But we have come to favor the suggestion offered many years ago by Robert,[5] in explanation of the local benumbing effect of certain electric currents, that the diminished perception results not from anesthesia or blocking, but from diversion of attention or confusion of consciousness; this supposed *central* phenomenon Robert termed "anesthésie de diversion," or "masking." In the spring of 1934 Lorin W. Denny, James C. Luce and I tested this matter upon ourselves; I described the experiments before the Association for Research in Nervous and Mental Disease in New York on December 27, 1934, and a detailed account is almost ready for publication; in view of the interesting work of Davis and Derbyshire, the following brief summary seems timely.

A cutaneous nerve, such as the radial, being completely blocked with procaine,[6] its cutaneous area was quite insensible to all forms of sensation; but the sense of deep pressure remained beneath the anesthetized skin, the impulses ascending from muscles, etc., through other nerves, *e.g.,* the ulnar (Fig. 1). The threshold for this deep pressure was measured

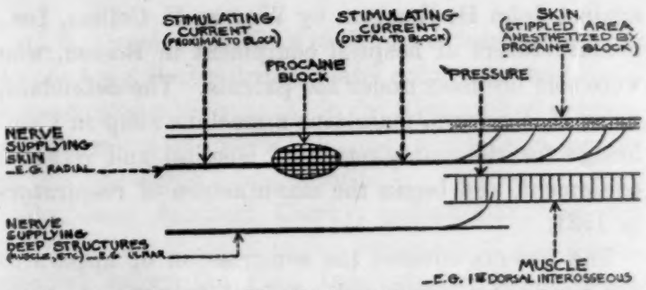

FIG. 1. Diagram illustrating the procaine block experiments described in the text.

(through the unfeeling skin) by the method described by Thompson *et al.*[4] Stimulation of the cutaneous nerve *distal* to the block evoked no sensation, and did not substantially alter the deep pressure threshold. Stimulation *proximal* to the block, however, not only aroused a normal tingling sensation projected into the anesthetized cutaneous area, but significantly elevated the threshold for deep pressure beneath that area, even though the nerves conducting impulses from the deep structures were affected neither by the anesthetic nor by the stimulating current. Moreover, in this type of experiment, stimulation of any nerve in the forearm or hand similarly raised the threshold for deep pressure beneath the anesthetized skin. It seems that perception of deep pressure (free from touch and superficial pressure) may be reduced, without interfering with the end-organs or the nerve involved, by suitably stimulating another nerve, if the impulses flowing from this stimulation succeed in reaching the sensorium and arousing a *sufficiently intense* sensation. We infer that the diminished perception in these experiments depends upon a central effect: to this we have applied Robert's term "masking," using it in his sense.

The important investigation of Davis and Derbyshire indicates that the difficulty in hearing a click simultaneously with a tone depends upon a peripheral effect—a physiological block. To call this "masking" introduces confusion into the literature, "masking" having already been preempted[2,3,5] to designate a *central* phenomenon, postulated by Robert, and demonstrated (we think) by us. It is to be hoped that some other term will be applied to the *peripheral* phenomenon elucidated by Davis and Derbyshire.

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[1] H. Davis and A. J. Derbyshire, *Proc. Amer. Physiol. Soc.,* April 10–13, 1935, p. 34; also reported in SCIENCE (Suppl.), 81: 6, 1935.
[2] I. M. Thompson and V. T. Inman, SCIENCE, 77: 216, 1933.
[3] I. M. Thompson, *ibid.,* 78: 268, 1933.
[4] I. M. Thompson, G. F. Banks, A. Barron, A. M. Fratis, Jr., and B. F. Mattison, *Univ. Calif. Publ. Anat.,* 1: 167, 1934.
[5] Robert, *L'Union Médicale,* 12: 487, 1858.
[6] Kindly donated by Eli Lilly and Company.

DRINKER RESPIRATOR PATENTS HELD INVALID

THE District Court of Massachusetts has recently held invalid three patents numbered 1,834,580, 1,906,453 and 1,906,844, granted to Philip Drinker and Louis A. Shaw in an infringement suit brought

against John H. Emerson by Warren E. Collins, Inc., manufacturers of hospital equipment in Boston, who were sole licensees under the patents. The defendant, John H. Emerson, maintains a machine shop in Cambridge for the manufacture of hospital and research equipment, and began the manufacture of respirators in 1931.

The patents covered the construction of apparatus for producing prolonged artificial respiration, especially for human beings suffering from infantile paralysis as well as in cases of gas poisoning, electric shock, drowning. These respirators worked admirably and were in great demand since 1929 for use in hospitals.

The court found that the defendant began to make his respirators after having seen the Drinker respirator. The defendant, however, excused his infringement on the ground that the patents were invalid because all the alleged novel features covered by the patents were old and disclosed in the prior literature.

After considering all the evidence and prior publications produced by the defendant the court agreed with the defendant that the Drinker patents were invalid. The important features of the patent claims of all three patents were found to be anticipated by prior publications, some as far back as 1876, or by prior issued patents.

The patent statutes permit the defendant in an infringement suit to excuse his acts if he can definitely prove that the patent or patents on which the suit is brought are invalid on account of prior knowledge, use or publication more than two years before the filing date of the patent application on which the patent was granted.

It is the duty of the Patent Office to make an investigation of prior practices and publications before granting patents, but owing to limited facilities, funds and personnel such investigations are not always thorough. Of course it must be borne in mind that defendants in infringement suits often employ experts at a cost of thousands of dollars who spend many months in order to uncover prior practices or obscure publications to anticipate issued patents. It is impossible for the Patent Office to make such thorough investigations at present on account of the larger number of patent applications filed each year. In the fiscal year 1934, for example, there were 60,363 patent applications filed in the Patent Office.

The patent statutes fortunately provide for the invalidation of erroneously issued patents, because it would be an injustice to enjoin the use of those apparatus, processes or compositions which are within the domain of public knowledge and hence free for any one to use for any desired purpose. The courts will therefore sustain and enforce only those patents which cover new and original inventions not known or used before by others within the statutory time limitation previously mentioned.

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ASCORBIC ACID IN CATARACT WITH SPECIAL REFERENCE TO DINITROPHENOL CATARACTS

THIS is a preliminary report of success in the treatment of the toxic effects of dinitrophenol, especially cataracts, and of cataracts of all types with ascorbic acid, vitamin C.

The presence of vitamin C in the normal lens in fairly high amounts has been confirmed by several workers, including Birch, Harris and Ray, Muller and Buschke, Gurewitch and others. With advancing age and with cataract formation the vitamin C content of the lens diminishes, and in some cataractous lenses may be entirely absent. The drop in the vitamin C content of the cataractous lens has been observed to parallel the drop in its glutathione content, as determined by Goldschmidt, Jess and Shoji, and also parallels the drop in its oxidative activity. Birch and Dann have adduced evidence that cevitamic acid and glutathione form part of the auto-oxidation system of the cell.

These data suggested the use of vitamin C in the form of ascorbic acid in cataract. Slit-lamp microscopic studies revealed that within a few days after administration of from 0.015 gm to 0.30 gm per day to patients with cataracts, marked improvement took place in the pathologic picture. First the swelling of the lens capsule was reduced and it became more transparent; and progressively the cells in the deeper layers improved in the same manner. Within less than a week of treatment mature and hypermature cataracts became sufficiently transparent to permit of examination of the eye-grounds, and vision improved from total or sub-total blindness to counting fingers. Cataracts involving vision less seriously responded at an equal pace, though in no case has the treatment been administered sufficiently long to determine whether the opacity of the lens will undergo total resolution.

The response of the very rapidly progressive dinitrophenol cataracts to ascorbic acid therapy was surprisingly rapid. When the treatment was intermitted, the cataract regressed; and progress was resumed with the resumption of treatment. Treatment was supplemented by food rich in glutathione content, in the hope that this element might also be replenished in the lens tissue, though our knowledge of the metabolism of glutathione is still so inadequate that there is no definite information available on this topic.

Other toxic symptoms of dinitrophenol poisoning such as the typical neuritis also responded promptly to the ascorbic acid therapy. This raises the question as to whether the toxic effects of dinitrophenol may not be due to the destruction of the auto-oxidative system elements of the cells as a result of the hyperoxidation which it induces, or whether it be due to direct chemical interaction with them.

The prophylactic treatment of all persons who have been the victims of dinitrophenol for reducing with the therapy in question is indicated; for a number of them who have been examined with the slit-lamp, in spite of the fact that there are no subjective symptoms, show early cataract formation.

An additional noteworthy finding in connection with the ascorbic acid therapy is the regeneration of lens fibers in an eye that had been aphakic following cataract extraction for many years. In this case, after two weeks of therapy, the lens capsule became filled out and the scarred anterior capsule of the lens, as well as the posterior, resumed its normal shagreen, and some of the fibers assumed normal transparency.

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THE DEVELOPMENT OF LIVER THERAPY IN ANEMIA[1]

PRIOR to 1922, no published records or reports are available of the use of liver in "sprue-anemia" by Sir Patrick Manson (1844–1922), although later editions of Manson's works revised by Manson-Bahr, of London, do contain mention of *liver soup* in the treatment of sprue. Sprue was first accurately described by Sir Patrick Manson[2] in 1880.

C. S. Engel, of Berlin (1898), used *"sanguinoform"* (made by a Berlin druggist and containing hog liver, stomach and other organs) in the treatment of anemia. He also noted an increase in eosinophiles from the use of this hog-organ preparation!

Professor Adalbert Czerny, pediatrician, did *not* mention liver therapy in the treatment of anemia of children before the First International Congress on Pediatrics, at Paris, in his paper on "Rapport sur l'Anèmie d'Origine alimentaire,"[3] as Oxenius, of Chemnitz, and George Roeder, of Rahway, N. J., claim.[4]

Hans Günther,[5] of Leipzig, refers to Engel's (1898) use of hog liver and stomach, but does not mention the work of Pirera and Castellino (1912) with liver in anemia nor the use of red bone marrow by Fraser (1894).

R. L. Fenlon[6] included liver in the diet for pernicious anemia patients.

R. B. Gibson and C. P. Howard, of Iowa City, gave liver daily, together with egg yolk and green vegetables, to anemia patients.[7]

Finally, Professor Alfonso Pirera, of Naples, in his article[8] on "Intorno ad alcuni problemi recenti di patologia epatica,"—Studio Sperimentale—mentions the research work (1912) with liver juice by Germano and Pizzini and Cafiero—using 12 injections of a concentrated liver preparation.

Pirera, of Naples, reviews the subject in his article "Epatoterapia ed emopoiesi epatica. Anemie da disepatismo."[9]

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SCIENTIFIC BOOKS

ATOMIC SPECTRA

Introduction to Atomic Spectra. By HARVEY E. WHITE. McGraw-Hill Book Company, N. Y. (1934). $5.00.

ONE of the most interesting chapters in some future history of contemporary physics will amaze the reader with an account of the rapidity with which physicists of the last two decades have brought order out of the apparent chaos of empirical information on the wave-lengths and intensities of spectrum lines. In 1924, one of the major problems of spectroscopy, namely, the cause of the fine structure of the alkali terms, was apparently in a hopeless snarl. There was no generally accepted notation for the cataloguing of spectral terms, and the confusion of the various schemes in use was an almost insuperable obstacle

[1] References: H. I. Goldstein, *Medical Review of Reviews* (New York), 41: 5, 227–229, May, 1935; *Medical Life* (New York), 42: 4, 207–216, April, 1935; *Wiener klin. Wochenschr.*, 16, 496–497, April 19, 1935; *Medical Record* (New York), 142: No. 3, pp. 136–138, August 7, 1935; SCIENCE, 80: 2085, 561, December 14, 1934; *La Riforma Medica*, 51: No. 7, 267–268, February 16, 1935; No. 9, 343–347, March 2, 1935.

[2] *Customs Gazette*, 1880.

[3] *Comptes Rendus de l'Ass'n. int. de Pédiatrie Premier Congrès* (7–9 Octobre, 1912), pages 91–101, 1913, G. Steinheil, Editeur, Paris.

[4] *Deutsche Med. Wochenschr.*, 60: 51, 1977, December 21, 1934; 61: 23, 929, June 7, 1935.

[5] "Uber Fortschritte in der Diättherapie," *Med. Klin.*, 27: 2, 48–50, January 6, 1931.

[6] *Jour. of Iowa State Med. Soc.*, XI: 2, 50, February, 1921.

[7] *Arch. Int. Med.*, 32: 1, 1–16, July, 1923.

[8] *Il Tommasi*, September 20 and 30, 1912, pages 601–617 and 625–636, Naples.

[9] *Rinascenze Medica* (Napoli), Anno XI, 13: 22, 683–685, November 30, 1934; 13: 23, 715–717, December 15, 1934.

to the student of the subject. The notation has now become standardized, and I think that most physicists would agree with me in the statement that at the present time there are no major outstanding problems in the field. Some spectra, for instance, those of some of the rare earths, have not been unraveled, but the difficulty lies only in their complexity, and is not due to the lack of basic principles on which to attack the analysis.

It is in this stage of the subject, that is, just after the sudden collapse of the main problems, and the almost instantaneous marshalling of the remaining facts under a few categories, that Professor White's book appears. His object, as stated in the preface, is to supply a treatise for the student approaching the subject for the first time. One ideal in such an undertaking would be to present the subject-matter in perfectly logical form, beginning with the smallest possible number of assumptions and explaining the phenomena encountered by deduction from these assumptions. Professor White has not attempted to write his book in this rigid Euclidean form, and I am quite certain that his choice is by far the wiser one. The subject of spectroscopy extends from the physical optics of gratings and prisms to the wave-mechanical treatments of radiating atoms and molecules. It seems to me that there is a well-defined intermediate region, in which one studies the interpretation of experimentally observed spectra by the use of the results of quantum mechanics, without going deeply into the technique of experimental spectroscopy or the mathematical manipulations which characterize the present stage of atomic theory. The book under consideration lies in this province. It contains excellent photographs of atomic spectra; quotes the results of wave-mechanics and shows how to link these together.

The book reflects what I consider to be a most commendably pragmatic attitude toward the theory. In spite of the advent of wave mechanics I think there are few who would discard completely Bohr's 1913 interpretation of the hydrogen atom, and I am pleased to see that Professor White has accorded it due prominence. Education in the subject consists largely in learning how far the successive models and vector diagrams may be trusted. These limits are extensively and adequately discussed in the book.

An especially good feature is the comparison of electron distributions according to the elliptic orbits of the classical quantum theory with those deduced from wave-mechanics. This is supplemented by a series of "pictures" of the hydrogen atom in various quantized states, with and without spin, which were ingeniously made by the author. The excellent diagrams of the Zeeman and Paschen-Back effects of terms arising from various electron configurations are also praiseworthy.

The first ten chapters of the book deal with single electron systems, appropriately beginning with hydrogen, and showing the relation between hydrogen terms and those of the alkalis and of alkali-like structures. In connection with the discussion of the periodic system, it seems to me that a statement of the *Aufbauprinzip,* or construction principle, is given which is open to criticism. On page 79 we read, "With quantum numbers assigned to each electron each atom Z in the periodic table is, so far as the extranuclear electrons are concerned, formed by adding one more electron to the atom Z-1." Either this statement has the entirely trivial meaning that an atom of atomic number Z has one more electron than the preceding atom in the periodic table, or it means that the electron configuration of the atom of atomic number Z is obtained by adding one electron to the electron configuration of atom Z-1. In this second sense the statement is not always true, for instance, in the case of 29Cu and 28Ni, where we have

28Ni	$1s^2$	$2s^22p^6$	$3s^23p^63d^8$	$4s^2$
29Cu	$1s^2$	$2s^22p^6$	$3s^23p^63d^{10}$	$4s$,

and the copper configuration is not that of nickel plus one electron. An idealized construction principle can be stated for the configuration of a small number of electrons about a nucleus of much larger charge. If to a hypothetical nucleus of charge 100e, 28 external electrons are added, the electron arrangement would not be that of nickel, but the addition of the 29th would not disturb the quantum numbers of the 28 previously present.

On page 86 we are rather abruptly introduced to element number 87 as "cornellium," which was my first aquaintance with this latest ebullition of college spirit. On page 170 we are given a quotation from a composite personage called Mullikan, who by slight vowel changes can be resolved into either of two well-known physicists.

The second part of the book deals with the spectra of atoms with more than one valence electron. The various coupling possibilities are adequately discussed, and in general, interval calculations, g-factor computations, etc., are carried out in full for both Russell-Saunders and jj coupling. The alternation law of multiplicities is strikingly illustrated by actual photographs of the spectra of the elements from 19K to 30Zn, taken by the author. I note by comparing pages 165 and 225 that Professor White has used the symbol Γ to represent the increase in the energy value of a term due to the interaction between the spin and orbital angular momenta of a single electron. Would it not be better to use γ for this purpose and reserve

Γ for the summation of the γ values which is important in complex spectra? The Γ sum rule and the Γ permanence rule are stated separately in sections 13.14 and 13.15. In this connection it is noteworthy that on pages 704–5 of the fifth edition of Sommerfeld's "Atombau" is found a treatment of these rules which shows that the sum rule can be developed as a consequence or corollary of the more general permanence rule.

In the chapter on x-ray spectra, the x-ray and optical terms of cadmium are shown on the same scale in Fig. 16.11, page 310. If we compare this figure with the optical terms of cadmium, shown in Fig. 11.6, page 179, we find that the configuration to which the wave-number zero is assigned is different in the two representations. In the optical case the wave-number zero is assigned to the configuration in which one of the outermost s-electrons is removed to infinity; on the optical-x-ray diagram the normal state of the cadmium atom is given wave-number zero. The former convention is undoubtedly the most commonly used one in optical spectra, and appears in Bacher and Goudsmit's "Atomic Energy States" for all spectra in which series limits are known. Whether a new convention should be adopted for diagrams showing the relation between x-ray and optical spectra I am not ready to state. If we retain the conventional optical assignment, all the x-ray terms have negative wave-numbers like the upper members of the displaced sequences in calcium, which are shown in an excellent diagram on page 182 of the book.

The application of the Γ permanence and Γ sum rules to x-ray spectra is not brought out, and Russell-Saunders term symbols are used for x-ray terms, which I believe assumes more about their coupling than is warranted by the information at hand.

An excellent feature of the book is the chapter on series perturbations and auto-ionization, which is the best treatment of the subject I have seen in book form. The book closes with an up-to-date account of the breadth of spectrum lines.

This book can be given unqualified approval as a text for graduate courses in atomic spectra. For the labor of its compilation the author deserves the thanks of every teacher and student of the subject.

SAMUEL K. ALLISON

GYMNOSPERMS

Gymnosperms, Structure and Evolution. By C. J. CHAMBERLAIN. Pp. xi + 484, 396 figures. University of Chicago Press, Chicago, Illinois. $4.50.

THIS book by Chamberlain describes the morphology and evolution of the gymnosperms, seed plants whose history extends back into the Paleozoic. The work is not only an excellent morphological treatise, but also includes many other phases of the subject. In it we find first-hand accounts of their geographic distribution and excellent photographs of the growth habit and habitats of these plants. Many restorations of the fossil forms add materially to the clearness with which the author describes the origin, history and evolution of the gymnosperms from the Carboniferous to the present.

In nearly every chapter, we find some of the author's own contributions to the subject, and throughout the book there is evidence that the findings of other investigators have been carefully checked and verified. Moreover, he has filled in many gaps in our knowledge of the morphology. Thus the book has the merit of being written by one who is thoroughly familiar with the material itself as well as the literature of the subject and who has devoted a lifetime to teaching and research in this particular field. A great majority of the excellent illustrations have been prepared by the author himself and about one third of them are entirely new.

The earliest records in the Paleozoic, reaching back at least 300 million years, show us that, included in this group, there are already two distinct lines which the author calls the Cycadophytes and Coniferophytes. The Cycadophytes are traced back to the Cycadofilicales; the Coniferophytes to the Cordaitales. These two lines appear to be distinct as far back as they can be traced in Paleozoic history. The two orders Bennettitales (or so-called "fossil cycads" of our texts on Historical Geology) and the Cycadales were both derived independently from the Cycadofilicales, not the cycads from the "fossil cycads." This last phase of their evolution occurred at the beginning of the Mesozoic. Likewise, the two orders of Coniferophytes, Ginkgoales and Coniferales, both lead back more or less independently to the Cordaitales, which became extinct at the close of the Permian. There is no connection between the Coniferophytes and any of the cone-bearing lycopods which flourished during the Devonian and Carboniferous. The Gnetales are much more recent and their origin is more obscure, though it seems evident that some of them show a definite affinity to the Coniferales, especially when we consider their embryogeny.

In his chapter on Cycadofilicales (often called the Pteridosperms), the author presents a very clear account of the structural features of this fossil material. Many excellent restorations are shown among the figures. Chamberlain also includes a series of hypothetical reconstructions of the essential steps in the evolution of the seed, based on a study of the seeds of Cycadofilicales. He defines a seed as a megasporangium which retains its megaspore and emphasizes the fact that the steps in the evolution of this structure

can not omit the stage of heterospory, as some eminent paleobotanists have suggested. The genetic line must have been: homosporous ferns; heterosporous ferns; seed plants. This thesis is very ably defended on morphological grounds.

The Cycadales, the only living representatives of the Cycadophytes, are presented in five chapters, including their geographic distribution, their life history, their gametophytes and fertilization, their embryogeny and seedling anatomy and their phylogeny and taxonomy. It is well known that Chamberlain has made notable contributions to the morphology of this group and in his chapter on their habitat and geographic distribution, he speaks with the authority of one who has studied them carefully in the field in various parts of the world. We find many new details on stem and leaf anatomy, on their gametophytes and on other structural features not previously included in similar books. In a discussion of hybrids among cycads several species crosses are described. A feature which should be of considerable interest to geneticists is the fact that generic hybrids have been obtained in the cross: *Ceratozamia mexicana* × *Zamia monticola*.

The chapters on Cordaitales and Ginkgoales indicate that there has been no great research activity in these groups in recent years. The author shows some excellent restorations of Cordaitales, and he has included some new figures and descriptions of features of the vegetative anatomy of Ginkgo.

Six chapters are devoted to the conifers, which include about four fifths of the genera of living gymnosperms. Here we find much new material selected from the literature which is reviewed, as well as original contributions. Many problems which remain are pointed out, so that the investigator of gymnosperms will find this book indispensable as a ready reference. There is much new material on the embryo, and the introductory chapter on the geographical distribution and habits of conifers shows that the author has also studied this group extensively in the field.

The Gnetales are treated in three chapters, including not only an excellent summary of the literature, but also some original studies on the details of floral organography in *Welwitschia*. Very little attention is given to the Caytoniales, whose phylogenetic position is still uncertain.

The final chapters are devoted to a discussion of phylogeny and the alternation of generations. The latter chapter is broadly inclusive—algae to seed-plants—and shows why the author holds strictly to the antithetic theory of alternation. A bibliography of 719 titles is included. The book is written in an attractive style and serves as an excellent text-book covering the morphology of gymnosperms, suitable for advanced courses in botany. For paleobotanists and students of historical geology, it presents the background essential to the interpretation of fossil seed plants and ferns. The investigator, if he is a beginner, will find this book indispensable as a ready reference; if he is an experienced investigator in the group, he will still find it essential for the numerous new and original contributions which it contains.

J. T. BUCHHOLZ

UNIVERSITY OF ILLINOIS

STATE ACADEMIES

THE NORTH CAROLINA ACADEMY OF SCIENCE

THE thirty-fourth annual meeting of the North Carolina Academy of Science was held at the Woman's College of the University of North Carolina, Greensboro, North Carolina, on May 3 and 4, 1935. About 265 persons, members and visitors, attended the meeting. Sixty-three papers and two exhibits were on the program. (The Proceedings and abstracts of most of these papers and several complete papers will appear at an early date in the *Journal of the Elisha Mitchell Scientific Society*.)

The first day was set aside for the presentation of papers before the General Section, after which was held the annual business meeting. The evening meeting was taken up with an address of welcome by Dean Geneva Drinkwater and the presidential address, "The Caprifoliaceae, or the Honeysuckle Family, in the Southeastern States," by the retiring president, Dr. H. R. Totten, professor of botany at the University of North Carolina. The addresses were followed by a social hour in Society Hall. The forenoon of the second day was set aside for the meetings of the following sections: General Section, Chemistry Section, Mathematics Section and Physics Section.

During the business meeting, a resolution of respect was read, honoring the memory of Dr. Collier Cobb, for many years professor of geology and chairman of the same department at the University of North Carolina.

The academy elected to life membership Dr. E. W. Gudger, of the American Museum of Natural History, and Professor R. N. Wilson, of the department of chemistry, Duke University. The executive committee reported the election of forty-three new members during the year and the reinstatement of seventeen former members.

In the high-school science essay contest, sponsored by the academy, first prize was awarded to Miss

Thelma Bardwell, Montreat College, for her essay entitled "Mental Hygiene." The prize was an excellent set of books on scientific subjects. The contest will be continued in 1935 in the fields of chemistry and physics.

The officers elected for 1935 are:

GENERAL ACADEMY

President, W. L. Porter, Davidson College.
Vice-President, F. W. Sherwood, State College.
Secretary-Treasurer, H. L. Blomquist, Duke University.
Executive Committee: The above officers and E. T. Browne, The University of North Carolina; W. E. Speas, Wake Forest College; H. R. Totten, The University of North Carolina.
Representative to the American Association for the Advancement of Science, Bert Cunningham, Duke University.

CHEMISTRY SECTION

Chairman, R. W. Bost, The University of North Carolina.
Vice-chairman, A. M. White, The University of North Carolina.
Secretary-Treasurer, W. C. Vosburgh, Duke University.
Councillor, L. A. Bigelow, Duke University.
Executive Committee: The officers and H. D. Sherwood, State College; H. D. Crockford, The University of North Carolina; J. S. Black, Wake Forest College.

MATHEMATICS SECTION

Chairman, W. N. Mebane, Jr., Davidson College.
Secretary, V. A. Hoyle, The University of North Carolina.

PHYSICS SECTION

Chairman, C. C. Hatley, Duke University.
Secretary, J. S. Meares, State College.

The thirty-fifth annual meeting of the North Carolina Academy of Science will be held in 1936 at Duke University, Durham, North Carolina.

H. L. BLOMQUIST,
Secretary

REPORTS

REPORT OF THE SUB-COMMITTEE ON SCIENTIFIC INVESTIGATIONS OF THE FISHERIES ADVISORY BOARD

THE fundamental contributions of science have aided materially in the development of the fishing industry and the conservation of the fish supply. Further researches and investigations and the application of the fundamental facts are necessary for the continued progress of the industry.

The committee recognizes the need of a better organization of scientific research and a more complete application of the technical knowledge so gained to the practical problems of fishery management and development. It is essential that all agencies define their objectives and prepare broad plans of research, into which may be fitted investigation of temporary or immediate problems in contradistinction to the haphazard development of unrelated projects. Coordination of these research programs of the several agencies is essential.

The economic prosperity of the commercial fisheries depends upon accurate continuous knowledge of the fluctuations and supply of raw materials of the industry, that can be obtained only through a systematic program of technical observation. These data will enable adjustment of the fishery business to the supply.

The conservation of game fish production depends upon management that implies intensive stream and lake surveys, the improvement of the environment especially through the abatement of destructive pollution, the stocking to maximum carrying capacity of artificially impounded waters and those restored to their natural state on submarginal land, and, lastly, the proper regulation of the use of such fish stocks.

FEDERAL FISHERY RESEARCH

The Federal Government should concern itself primarily with investigations of a fundamental nature having the widest application both scientifically and in a geographic sense. Variation in abundance of commercial fishes, migratory habits of fishes, particularly in interstate waters, and the accumulation of data upon which the prediction of future runs may be based; the prevention of the destruction of migratory fish on federal reclamation projects; the survey and improvement of streams and lakes in national parks and forests; studies of the means of abating water pollution and the development of rational plans for restocking waters are suggested as types of research especially suitable for federal consideration.

Projects supported by emergency appropriations have their merit, but can not be substituted for a long-time program of scientific fishery research. A well-trained and experienced personnel, adequately compensated and reasonably sure of tenure of office, is necessary to carry out a continuing program of research.

The committee deplores the recent tendency to economize in the direction of reducing expenditures for research of such types which are vital to the national welfare. The "White Act," approved on May 21, 1930, authorized progressive increases in the federal appropriation for biological fishery research, amounting to $60,000 annually for five years, and for

technological and economic fishery research, amounting to $35,000 annually for five years. The purpose of such a program was to develop research of the type outlined by this committee. Failure to secure the authorized appropriation, however, has nullified the purpose of the act. The committee strongly urges the early resumption of the authorized plan of development.

Another authorization by Congress, approved June 21, 1934, which has failed of realization provides for the construction of a marine research vessel, without which many of the fundamental problems of the marine fisheries can not be solved. The United States is the only first-class maritime nation without such a research vessel. Such facilities should be furnished as soon as possible.

Fishery Research by State Agencies

The problems best handled by state research agencies are those of more local significance that will guide the enactment and enforcement of protective regulations, or that will result in the promotion and extension of the local fishing industries and game fish supply. The program of research should be integrated with the programs of the Federal Government and coordinated with those of the neighboring states. States may meet this need for investigation by the establishment of research units in their conservation commission, or by the utilization of existing state agencies. Such units should be staffed by trained personnel to be appointed on the basis of merit, with reasonable assurance of tenure of office. Close cooperation between state-supported educational institutions and conservation officials is urged.

Stimulation of Research by Private Agencies

In contrast with conditions in Europe and Japan, where progress in aquatic biology comes chiefly from university men, few scholars in this country are devoting themselves to aquatic biology. Universities, scientific foundations and private institutions and associations should be encouraged to devote more attention to the biological problems involved in conservation of natural resources through the creation or allocation of grants in aid, fellowships and professorships in existing institutions. The Federal Government, state conservation departments, research foundations and sportsmen's organizations should cooperate in this program by allocating funds for such purposes.

Finally, the committee recommends that in order to make the results of scientific investigations available and practically applicable, adequate funds for the prompt publication of technical reports resulting from such studies should be made available by all agencies concerned.

R. V. Truitt, *Chairman*

SPECIAL ARTICLES

FURTHER DATA ON THE EXISTENCE OF EXTRA-CHROMOSOMAL INFLUENCE ON THE INCIDENCE OF MAMMARY TUMORS IN MICE

In 1933 the writers[1] included the result of two crosses among the data advanced by the staff of the Jackson Memorial Laboratory to demonstrate extra-chromosomal influence on the incidence of mammary tumors in mice.

These crosses were between an inbred strain of dilute brown mice (dba) high in incidence of mammary tumors and another inbred strain (C57 black) in which no such tumors have been recorded.

The F_1 generation produced by dilute brown females × C57 black males gave mammary tumors in 39.82 per cent. of the 113 virgin females which lived to reach "cancer age." The 664 F_2 generation animals, descended from similarly constituted F_1 females crossed with their brothers, gave 35.29 per cent. mammary tumors.

The reciprocal F_1 generation derived from C57 black females × dilute brown males gave 6.06 per cent. mammary tumors in 379 mice, while the 688 F_2 females obtained from inbreeding these F_1 animals gave 5.96 per cent. with mammary tumors. The detailed results of these completed experiments will be published in the September, 1935, number of *Genetics*.

So striking was the difference between the reciprocal crosses that it seemed desirable to produce and study certain back-cross generations. While most of the animals produced for this purpose are still alive, the preliminary results so far obtained are sufficiently interesting to justify publication.[2]

In order to understand the plan of the experiment it will be desirable to use the following symbols to designate the genetic contribution of the different strains:

C = chromosomal material derived from high mammary tumor strain—dba.

c = chromosomal material derived from non-mammary-tumor strain—C57 black.

E = extra-chromosomal influence derived from high mammary tumor strain—dba.

[1] Science, 78: 465–466.

[2] The population of virgin females from which the final data are to be derived consists of 250 mice in each of four crosses.

= extra-chromosomal influence derived from non-mammary-tumor strain—C57 black.

The contribution of the female is shown as the numerator of a fraction; the male contribution as the denominator. Thus, a dba female is expressed by $♀\frac{CE}{C}$ and a dilute brown male as $♂\frac{C}{C}$; while a C57 black female is $♀\frac{ce}{c}$ and a male $♂\frac{c}{c}$.

Four types of back-cross were made as follows:

I. F_1 $♀\frac{ce}{C} \times ♂\frac{C}{C}$—containing *three* high mammary tumor chromosomal contributions and *one* non-mammary tumor. Extra-chromosomal influence non-mammary tumor.

II. $♀\frac{CE}{C} \times F_1$ $♂\frac{c}{C}$—similar to I except extra-chromosomal influence is from high mammary tumor strain.

III. F_1 $♀\frac{ce}{C} \times \frac{c}{c}$—containing *three* non-mammary tumor chromosomal contributions and *one* high mammary tumor. Extra-chromosomal influence non-mammary tumor.

IV. F_1 $♀\frac{CE}{c} \times \frac{c}{c}$—similar to III except extra-chromosomal influence is from high mammary tumor strain.

The total number of virgin female mice which have died in each cross, together with the incidence of mammary tumors, is as shown in Table 1.

TABLE 1

	Total mice dead	Non-mammary tumor	Mammary tumor	Per cent. mammary tumor
I	10	10	0	0.0
II	47	16	31	65.9
III	13	13	0	0.0
IV	23	7	16	69.5
Total...	93			

In crosses I and II the chromosomal contributions to female back-cross mice by their F_1 parents should be equal, three being from the high tumor strain and one from the non-tumor strain. The extra-chromosomal influence was, however, obviously very different, being from the high tumor strain in II and from the non-tumor strain in I.

The high incidence of mammary tumors does not follow the high tumor chromosomes, but is found in the cross where the extra-chromosomal influence is derived from a high tumor strain. The percentages are strikingly distinct, being 0 for I and 65.9 for II.

Further evidence of the relative unimportance of the chromosomes is to be found in a comparison of I and III. Here the extra-chromosomal contribution is similar in the two crosses, both being from the non-tumor strain. A C57 black male with no "high tumor" chromosomes was used in III, producing animals with three non-tumor and one high tumor chromosomal contributions. In I an F_1 with "high tumor" chromosomes derived from a dilute brown mother was used. The total chromosome contribution was the reverse of III, being three "high tumor" to one non-tumor. Although this great chromosomal difference exists, neither cross has as yet formed a mammary tumor. Later figures may, however, modify this result somewhat.

Cross I compared with Cross IV is interesting in that I introduces $\frac{3}{4}$ high tumor chromosome contribution, $\frac{1}{4}$ non-tumor, with non-tumor extra-chromosomal influence and gives 0 per cent. mammary tumors while IV introduces $\frac{3}{4}$ non-tumor chromosomes and $\frac{1}{4}$ high tumor and high tumor extra-chromosomal influence, giving 69.5 per cent. mammary tumors.

Cross II compared with Cross III presents a slightly different situation. Cross II combines $\frac{3}{4}$ high tumor and $\frac{1}{4}$ non-tumor chromosomes with a high tumor extra-chromosomal influence. Its incidence of mammary tumors is 65.9 per cent. Cross III is the opposite, having only $\frac{1}{4}$ high tumor chromosomes and a non-tumor extra-chromosomal influence. Its tumor incidence is 0.

Cross II may also be compared with Cross IV. In this case, although the chromosomal contributions are diametrically opposite, being $\frac{3}{4}$ high tumor in II and $\frac{3}{4}$ non-tumor in IV, *both* crosses have high tumor extra-chromosomal influence. The percentages of tumor incidence are 65.9 and 69.5, respectively. It is interesting to note that while the incidence is as nearly identical as could be expected, the slight excess that does exist occurs in the cross with *more* "non-tumor" chromosomes. The significance of this fact is, however, doubtful.

In a comparison between Crosses III and IV the chromosome situation is identical in the two crosses, but the extra-chromosomal contribution of IV is directly transmitted from a high tumor dilute brown grandmother, while III has no such derivation. In this case the incidence of tumors is strikingly different, being 0 per cent. in III and 69.5 per cent. in IV.

It will be noted that the incidence of mammary tumors in back-crosses II and IV (65.9 and 69.5 per cent.) is distinctly higher than in the F_1 and F_2 generations which were derived from high tumor female ancestry (39.82 and 35.29 per cent.). The significance of this difference is at present doubtful. It is quite possible that as larger numbers of non-tumor

animals begin to die in the older age groups of the back-cross it will tend to lower the final percentage of tumors in these generations. If the present high tumor incidence of mammary tumors in Cross II persists it might be considered the result of chromosomal influences from the dilute brown chromosomes. Cross IV, however, should be actually no greater than on the F_1 and F_2 generations above mentioned. If, therefore, chromosomal influences are operative to any measurable degree Cross IV should eventually show no higher incidence of mammary tumors than 40 per cent., while Cross II should remain appreciably higher than that figure. Further data are needed to settle this point.

The relative age of the populations in the four crosses is a factor to be considered. The mean age in days of the four is as follows: I, 499; II, 444; III, 439; IV, 431. It will be noted that such difference as exists has resulted in as good or better chance for the crosses showing no mammary tumors as for those showing them.

While the incidence of mammary tumors has shown a clearly "extra-chromosomal" type of distribution, the two pairs of mendelian color factors B black—b non-black (brown), and D intense—d, dilute have segregated normally. The actual count in the two crosses where such segregation was discernible is given in Table 2.

TABLE 2

	Black	Dilute black	Brown	Dilute brown	Total
I					
Observed	170	162	134	172	636
Expected	159	159	159	159	638
II					
Observed	163	133	128	152	576
Expected	144	144	144	144	576

The experiments are being continued and will be fully discussed on their completion. It should be clearly understood that larger numbers of animals may modify somewhat the quantitative values of the various groups. On the other hand, there is little doubt that the major difference between Groups II and IV, on one hand, and I and III, on the other, will persist.

Although the numbers of mice so far autopsied in Crosses I and III are small, the absence of mammary tumors is interesting and may, if it persists, have considerable significance. The fact that the completed series of F_1 and F_2 animals, to which reference has been made, showed in all crosses some mammary tumors remains to be explained by further experimentation. Using the symbols already employed, the F_1 and F_2 generations may be tabulated as follows:

dBF_1 ♀ $\frac{CE}{C} \times$ ♂ $\frac{c}{c}$ = 39.82 per cent. mammary tumors in 113 mice

BdF_1 ♀ $\frac{ce}{c} \times$ ♂ $\frac{C}{C}$ = 6.06 per cent. mammary tumors in 379 mice

dBF_2 ♀ $\frac{CE}{c} \times$ ♂ $\frac{C}{c}$ = 35.29 per cent. mammary tumors in 664 mice

BdF_2 ♀ $\frac{ce}{C} \times$ ♂ $\frac{C}{c}$ = 5.96 per cent. mammary tumors in 688 mice

We may thus conclude that in the four types of back-cross cited, the incidence of mammary tumors in mice depends primarily upon the direct transmission of extra-chromosomal influences. This confirms completely the earlier experiments with F_1 and F_2 mice.

Grateful acknowledgment is made to the American Philosophical Society for a grant to assist in support of this work.

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ADRENAL INSUFFICIENCY IN THE MARMOT AND OPOSSUM AND THEORIES OF CORTICO-ADRENAL FUNCTION

COMMON laboratory animals (cat, dog, rat, rabbit, guinea-pig) which have been adrenalectomized show diminutions in serum sodium and chloride content, and Addisonian patients in crisis are apparently similarly affected.[1, 2, 3, 4] It has also been demonstrated that an increased renal excretion of sodium and chloride is either the result or the cause of the subnormal values found in blood serum and tissues after adrenal removal. If compensation for excessive loss of sodium chloride is made by the injection or oral administration of saline, adrenal insufficiency is said to be relieved[2, 3, 5]; again, if the sodium content of the body is reduced experimentally, a condition resembling that of adrenal insufficiency is said to result.[7]

On the basis of these observations several experimenters have expressed the belief that the adrenal cortex is intimately concerned with sodium chloride

[1] H. Silvette and S. W. Britton, *Amer. Jour. Physiol.*, 104, 399, 1933; *ibid.*, 108, 535, 1934; *ibid.*, in press; also unpublished results.

[2] R. F. Loeb *et al.*, SCIENCE, 76: 420, 1932; *Proc. Soc. Exp. Biol. Med.*, 30: 808, 1933; *Jour. Exp. Med.*, 57: 775, 1933.

[3] G. A. Harrop *et al.*, *Jour. Amer. Med. Assoc.*, 100: 1850, 1933; *Jour. Exp. Med.*, 57: 305; *ibid.*, 58: 1, 17.

[4] W. W. Swingle *et al.*, *Amer. Jour. Physiol.*, 107: 259, 1934.

[5] J. M. Rogoff, *Jour. Amer. Med. Assoc.*, 103: 1764, 1934.

[7] A. Gilman, *Amer. Jour. Physiol.*, 108: 662, 1934.

metabolism, and that death after adrenalectomy probably occurs because of reductions in sodium and chloride concentration and correlated derangements of blood volume and tissue fluids.[2, 3, 4]

It appeared significant indeed that all the animal types which have been investigated showed reductions in sodium and chloride values after adrenal removal. Diminutions in blood sugar and liver and muscle glycogen were moreover concurrently observed.[1, 8] Blood sugar and liver glycogen values were reduced in many cases, indeed, to the point of exhaustion. Several years ago one of us[6] pointed out that the adrenal cortex appeared to have its main action on carbohydrate metabolism, and recent results have confirmed this belief.[8] The challenge to our carbohydrate theory of cortico-adrenal function by what may be termed the sodium chloride theory has led us to investigate the issues further.

In this connection we have for some time entertained the possibility of finding an animal species in which the two groups of phenomena, *i.e.*, the carbohydrate and sodium chloride changes, might perhaps be separated by nature—an animal type in which, for example, the carbohydrate levels might become reduced following adrenalectomy while the salt content might remain normal, or *vice versa*. In such case the primary responsibility for the adrenalectomized animal's death might be directly indicated.

Functional conditions in the opossum (*Didelphys virginiana*) and the marmot (*Arctomys monax*), we have now discovered, offer a key to the solution of the problem. Following adrenalectomy these animals progressively lose weight, show anorexia and all the general symptoms of insufficiency, and eventually die in typical hypoglycemic convulsions. If such animals are sacrificed when insufficiency symptoms appear the blood sugar is found to be very low, and muscle and liver glycogen are profoundly decreased as in the case of the commoner laboratory animals. Serum sodium and chloride values show a definite *increase*, however, over the normal controls, and the sodium chloride content of the muscles also appears to be increased. The muscle water percentage was observed, furthermore, to be significantly reduced. Sodium chloride and water balance are therefore strikingly different in the marmot and the opossum from any other species which have been investigated to date.

Analyses of the daily urinary output of opossums before and after adrenalectomy are in correlation with the above observations: daily excretion of sodium chloride is considerably *less* after operation than before.

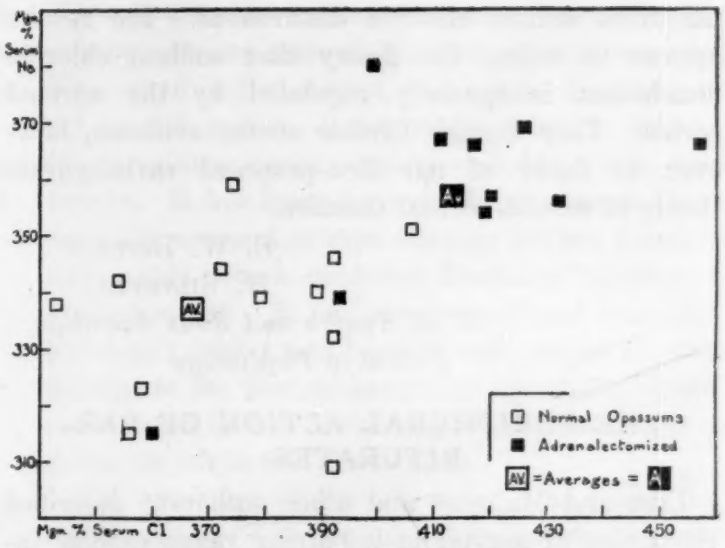

FIG. 1. Serum sodium and chloride levels in normal and adrenalectomized opossums.

In other experimental animal types, sodium chloride elimination is in contrast greater after adrenal excision.[1, 2, 3, 4, 9] The graph herewith depicts the sharp contrast in the opossum in serum sodium and chloride levels before and after adrenal ablation.

The opossum, it is appreciated, represents one of the lowliest of mammalian types, and it has been said that the marmot is a very ancient form. Marsupial nursing and hibernating activities are undoubtedly to be listed among the more primitive functional characteristics of mammals. It is nevertheless hardly conceivable that the internal secretory mechanisms of these animals should differ in any notable degree from those observed in the case of other laboratory animals. Although not categorical in their expressions, hormones do appear to exert their influence with duplicable uniformity through different animal species. Thus, if sodium chloride metabolism were controlled through cortico-adrenal function in one animal, it would probably be regulated similarly in others.

The opossum and the marmot apparently metabolize carbohydrates in essentially the same manner as higher mammalian types. Salt and water balance after adrenal excision, however, is not at all similar to that found in other adrenalectomized animals. The evidence indicates that the adrenal cortex is not specifically involved in the control of sodium and chlorides in the organism. It appears singular that adrenalectomy should lead to opposite effects on sodium chloride in different animals. The possibility that cortico-adrenal activities are related to kidney function may be entertained. It is perhaps more significant, however, that in their carbohydrate economy the Virginian marsupial and the marmot run true to higher forms.

It is concluded that the adrenalectomized opossum and marmot die from carbohydrate insufficiency and

[8] S. W. Britton and H. Silvette, *Amer. Jour. Physiol.*, 100: 693, 701, 1932; SCIENCE, 77: 366, 1933; *Amer. Jour. Physiol.*, 107: 190, 1934.

[6] S. W. Britton, *Physiol. Rev.*, 10: 617, 1930.

[9] M. I. Rubin and E. T. Kricke, *Proc. Soc. Exp. Biol. Med.*, 31: 228, 1933.

not from sodium chloride disturbance. The results appear to refute the theory that sodium chloride metabolism is specially regulated by the adrenal cortex. They furnish further strong evidence, however, in favor of our first-proposed carbohydrate theory of cortico-adrenal function.

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THE PERIPHERAL ACTION OF BARBITURATES[1]

LIEB and Mulinos[2] and other authors[3,4] described the action of amytal in impairing vagus cardiac inhibitory effects. According to Swanson and Shonle,[5] this action was regarded as characteristic for amytal, since a closely related barbiturate, iso-amytal (1-methyl-butyl ethyl barbituric acid or pentobarbital), failed to produce a similar peripheral depression of the cardiac vagus in doses of 5 to 20 mgm per kgm.

In a large series of experiments, using dogs and rabbits, we confirmed the original observation of Lieb and Mulinos with amytal. We found that amytal in doses ranging from 50 to 60 mgm per kgm abolished the typical cardiac vagus effect, *viz.*, the cardiac inhibition which resulted from stimulation of the peripheral vagus. Experiments of a similar nature revealed the fact that this peripheral action of amytal is also exhibited after very large doses of pentobarbital-sodium and other barbiturates. The animals used in these experiments were kept alive with picrotoxin. Doses of pentobarbital-sodium varying from 40 to 100 mg and barbital-sodium in doses of 500 to 1,100 mgm p kgm completely abolished the typical vagus respon to faradic stimulation. Phenobarbital-sodium in do of 100 to 350 mgm per kgm impaired but did not ab ish the cardiac vagus effect. In all these instanc where the peripheral vagus effect had been abolish by barbiturates, the central vagus effects, *e.g.*, t respiratory inhibition following the faradic stimul tion of the central end, remained unimpaired.

The mechanism of the depression of the cardi vagus function by barbiturates was disclosed by a other series of experiments. The following facts re tive to this problem have been ascertained:

(a) Pilocarpine (1 mgm per kgm) slowed the h of barbiturate-treated animals which did not respo to peripheral vagus stimulation.

(b) Large doses of acetyl choline (0.1 mgm p kgm) produce vasodilation and cardiac inhibition the animals which had received barbiturates.

(c) Doses of physostigmine (0.2 to 0.35 mgm p kgm) which were insufficient to produce slowing the heart rendered the cardiac vagus sensitive to far dic stimulation. Also large doses of acetyl choline h the same effect after the blood pressure and heart r returned to the original level.

These experiments suggest that the cardiac vag impairing action of barbiturates is not an atropin like action but probably a nicotine-like effect on t vagus ganglia.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A SIMPLE TYPE OF ERGOMETER

IN order that the greatest value may be obtained from many laboratory experiments in human physiology it is desirable that students, particularly those in the preclinical years of medicine, understand the relationship between basal manifestations and known amounts of activity. Ergometers, when constructed to give a reasonably accurate measure of the work performed, are usually so costly that one piece of apparatus is to be found in a laboratory. Hence experiments must be either done by very large groups or the experiment conducted as a demonstration.

It has been the policy in the author's laboratory to correlate to a maximal degree the effect of known amounts of activity with the various physiological systems. In order to do this a simple yet efficient ty of ergometer has been devised of such a nature th each table of a special laboratory devoted to huma physiology is equipped with this device. The arrang ment has proven of great convenience, since studen have an opportunity to evaluate the effect of grad activity upon such physiological manifestations a blood pressure, pulse rate, metabolism and respiratio A further definite advantage of the apparatus res in the fact that preliminary measurements can b taken under nearly basal conditions, which is not tru of many common forms of ergometer.

The ergometer is constructed at one end of a tabl 72 × 30 inches, with legs of sufficient height that th usual type of clinical metabolism apparatus may b

[1] From the Department of Pharmacology and Materia Medica, Georgetown University, School of Medicine, Washington, D. C.

[2] Lieb and Mulinos, *Proc. Soc. Exper. Biol. and Med.*, 26: 709, 1929.

[3] Shafer, Underwood and Gaynor, *Am. Jour. Physiol.* 91: 461, 1930.

[4] Garry, *Jour. Pharmacol. Exper. Therap.*, 39: 12 1930.

[5] Swanson and Shonle, *Jour. Lab. and Clin. Med.*, 16 1056, 1931.

rolled into place and adjusted to the subject without changes in the connections. It has been found that this area of table top is sufficient to permit a student to lie relaxed and yet allow space for a kymograph and the necessary stativs to carry the recording apparatus. The construction of the ergometer is very simple. This may be seen in Fig. 1. An upright

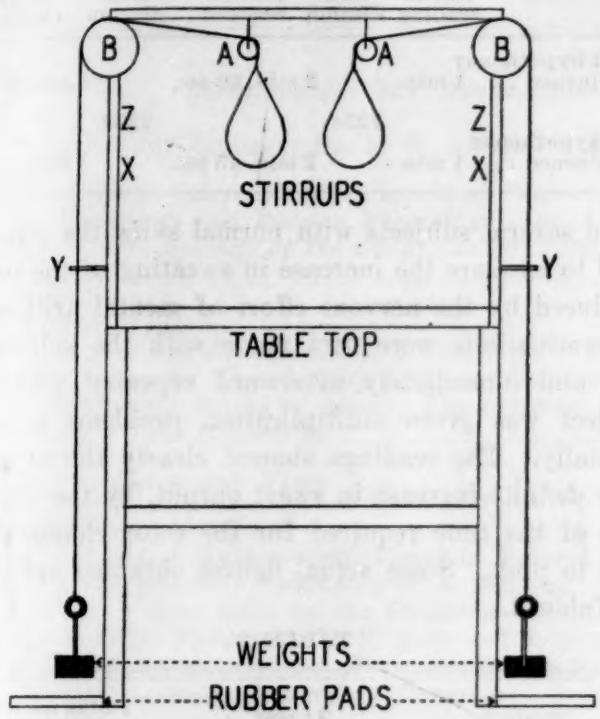

FIG. 1.

frame of 1-inch angle iron, 30 inches high by 30 inches broad, is bolted firmly to the table top by means of lag screws and braced by 1-inch × ⅛-inch steel strips fastened at points X and to the table at a point 30 inches from the base of the ergometer frame. These steel braces serve a second purpose, since they may form a grip for the subject during the course of vigorous exercise. Work is performed by extension and flexion of the legs raising known weights. The subject lies in a supine position with each foot in a stirrup formed by a loop of cord. These cords each pass over two pulleys. One (A) is suspended from a swivel about ten inches from the angle of the frame. The second (B) is bolted to the frame in such a manner that the edge of the pulley gives adequate clearance, thus avoiding friction due to the rubbing of the cord against other parts of the structure. It has been found necessary to insert an eye bolt (Y) near the bottom of the ergometer frame to prevent oscillations and bumping. This further serves as a marker in measuring the distance the subject extends his leg. The cord terminates in an 8-inch eye bolt which is screwed into a 2.5 kilogram weight. The arrangement using a 2.5 kilo weight has been found to be about the most efficient minimum load we can use. Each pulley and cord is supplied with three additional weights so that a maximum load of ten kilos on each leg may be attained. The weights are made of cast iron in the form of a cylinder 4 inches in diameter and 1⅝ inches high. A casting of gray iron of this size slightly exceeds 2.5 kilos when drilled with a ⅝-inch hole, through which the eye bolt passes. It is a simple matter to drill away the remaining excess iron in order to attain correct weight. It has been the writer's experience that the most efficient cord or rope one may use is a ¼-inch steel tiller cable, which combines flexibility together with great strength. It has also been found desirable to put a soft rubber pad beneath each weight to prevent damage to the floor, although the apparatus should be so adjusted that in the zero position the weight just clears the surface of the cushion.

The operation of the ergometer is as simple as its construction. With the subject in the supine position with his feet in the stirrups and with weights added commensurate with the amount of work to be done, the basal readings are taken. At the same time the member of the group responsible for the ergometer marks with chalk the position Y on the steel cable and a second position Z on the frame. The point Z is determined by the distance the subject can extend his legs without danger of the weights hitting the table. It is not at all difficult during a preliminary test to adjust even a long-legged individual to such a position that the movement of the weights from Y to Z will represent a maximal extension without mechanical interference. During the period of work the subject alternately extends his legs in a predetermined rhythm, during which time a record of the number of kicks per minute is recorded. Knowing the height to which the weights are raised by each leg and the number of kicks per minute it is a simple matter to compute the amount of work done. We have found that flashing lights controlled by an electric sign flasher are very valuable in signalling the interval for extension and relaxation. Exercise of this type and in this position has a distinct advantage where apparatus must be carefully adjusted to the subject. We have found little difficulty in recording carotid pulse waves during quite heavy exercise without disturbance of the receiving tambour. On the other hand, the amount of work done using the ten-kilo load on each leg at a maximal rate is sufficient to build up a considerable oxygen debt in a short bout of exercise.

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A METHOD FOR MEASURING SWEAT OUTPUT FROM SKIN SURFACES

MEASUREMENT of the "perspiratio insensibilis" has interested investigators since Sanctorius in 1614 began his observations on the weight loss of the body by means of a large balance of his own construction. Numerous methods and devices have since been devel-

oped for determining the amount of the sensible and insensible perspiration and great degrees of accuracy have been attained; but all these are too cumbersome for routine clinical use.

With the idea of simplicity in method and equipment in mind, we have devised the following technique for the estimation of sweat output in terms of time with sufficient accuracy for use by the clinician. It must of course be considered an empirical method because the chemistry of the various hydrates of cobaltous chloride is extremely complex and still under study. The determinations by this method can not thus be considered precisely quantitative, but they do give a fairly accurate index of the amount of secretion.

PRINCIPLE

Cobaltous chloride is a salt of blue color in its anhydrous state, but which turns distinctly pink after taking up six molecules of water of crystallization. There are intermediate hydrates formed, containing less than six molecules of water, but none of these are of a pure pink color. The hydrates of cobaltous chloride readily give up all their water on heating to 140° C., forming the blue anhydrous salt. The color change may be graphically expressed by the following equation:

$$\underset{\text{(blue)}}{CoCl_2} + 6\,H_2O \rightleftarrows \underset{\text{(pink)}}{CoCl_2 \cdot 6\,H_2O}$$

METHOD

A special bibulous sheet is treated by immersion in a standard 10 per cent. solution of cobaltous chloride, allowed to dry and then cut into strips of suitable size for use. Any good grade of fine-grained perfectly white filter paper may be substituted. Just before use, the strips of this treated paper are thoroughly dried in an oven at 140° C. and then placed upon the area of skin to be studied and immediately pressed to the surface by an ordinary glass diascope. The time required for a complete change in color from blue to a pure pink is observed and recorded. Since the paper contains a standard concentration of anhydrous $CoCl_2$ when blue, and since it requires a definite amount of water to completely change this into the pink hydrate $CoCl_2.6\,H_2O$, the time observed for the color change corresponds to the time required by the sweat glands of the area under study to secrete this amount of water.

APPLICATION

Up to the present we have employed this method to determine relative changes in, rather than absolute amounts of, sweat secretion. Several patients under treatment with x-ray for a dermatosis associated with excessively sweaty palms were followed by this test to determine its practicability in measuring the progressive decrease of sweat secretion under roentgen irradiation. In Table 1 is a typical set of readings obtained at weekly intervals.

TABLE 1

	Initial reading	Irradiation	Second reading	Irradiation	Third reading
Right hypothenar eminence ..	1 min.	125r	2 min. 30 sec.	125r	4 min. 30 sec.
Left hypothenar eminence ..	1 min.		2 min. 45 sec.		4 min.

On several subjects with normal skins the test was used to measure the increase in sweating of the palms produced by the nervous effort of mental arithmetic. Determinations were first made with the subject at rest and immediately afterward repeated while the subject was given multiplication problems to solve mentally. The readings showed clearly the expected very definite increase in sweat output, by the diminution of the time required for the color change from blue to pink. Some actual figures obtained are given in Table 2.

TABLE 2

Subject	At rest	Doing mental arithemetic
A	9½ min.	4½ min.
B	10 min.	3 min.
C	10 min.	6½ min.

This method of measurement is in process of calibration, so to speak, by making simultaneous quantitative determinations by means of one of the older methods. But even without determining the absolute value of the sweat output the test has a definite practical clinical value in observing and recording the relative changes in local sweat output under treatment; or the increase or decrease of sweat due to nerve injuries; or the study of the influence of temperature, muscular exercise, emotions, mental effort, etc., on the sweat output of various portions of the skin surface.

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